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TREATISE

ON

ORTHOPEDIC SURGERY

BY

EDWARD H. BRADFORD, M.D.

Surgeon to the Children's Hospital and to the Samaritan Hospital; Assistant Professor of Orthopedic Surgery, Harvard Medical School

AND

ROBERT W. LOVETT, M.D.

Assistant Surgeon to the Children's Hospital; Surgeon to the Infants' Hospital

ILLUSTRATED WITH SIX HUNDRED AND TWENTY-ONE ENGRAVINGS

Second Revised Edition

NEW YORK

WILLIAM WOOD AND COMPANY

MDCCCXCIX

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PREFACE.

The progress of orthopedic surgery in the last nine years has been so rapid that a revised edition of this work has necessitated very largely the rewriting of the entire book. But few changes in its scope or classification have been made; some subjects, however, treated in the former book have been omitted while others have been more fully considered. We are indebted to many of our friends, especially to our fellow-members of the American Orthopedic Association and to the managers of the Children's Hospital, for the use of their illustrations.

Edward H. Bradford.
Robert W. Lovett.

Boston, September, 1899.

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ORTHOPEDIC SURGERY.

CHAPTER I.

POTT'S DISEASE.

Definition.—History.—Pathological Anatomy.—Occurrence and Etiology.—Symptoms.—Diagnosis.—Differential Diagnosis.—Prognosis.—Treatment.

Definition.—Pott's disease is the name applied to a destructive pathological process which attacks the bodies of the vertebræ. The other names by which the affection is known are as follows: Spondylitis, *Malum Pottii*, Caries of the spine, Kyphosis, Angular curvature, Tuberculosis of the vertebræ, and Spinal curvature. In German it is known as *Die Pott'sche Kyphose, Spitzbuckel, Winkelförmige Knickung der Wirbelsäule,* and *Tuberculose Wirbelentzündung;* in French as *Cyphose, Mal de Pott,* and *Mal Vertébral.*

History.—Antero-posterior curvature of the spine is an affection which was described by the ancients, and was known to Hippocrates and Galen, who attributed its cause to tubercle "within and without the lungs." Ambroise Paré wrote of it and used a metal cuirass in its treatment, but it was not until the time of Percival Pott in 1779 that any accurate description of the disease was given.[1] In honor of that surgeon the disease is chiefly known by his name. The existence of the disease in prehistoric times in North America is evidenced by a specimen in the Peabody Museum, Cambridge, Mass.

Pathological Anatomy.

Pott's disease represents the result of a destructive ostitis affecting the spongy tissue of one or more of the vertebral bodies. This ostitis, so far as we now know, is tuberculous in type and follows the same course as tuberculous ostitis occurring at the epiphyses of the long bones, as in hip disease, tumor albus, etc.

The first appearance noticeable to the naked eye on examining a section of a diseased vertebra at an early stage of the disease is a small

[1] Pott: "Remarks on that Kind of Palsy Affecting the Lower Limbs," etc., London, 1779.

hyperæmic spot in some part of the spongy portion of the body of the vertebra, generally near the anterior surface of the body. This spot grows larger and more red as the process extends, and finally the centre becomes opaque and grayish, while a zone of hyperæmia surrounds it. A focus of tuberculous ostitis is present. If this process extends, the opaque spot becomes larger, and finally cheesy degeneration of its centre takes place. At other times both caseation and degeneration into tuberculous pus take place, and a localized abscess of bone exists, probably encapsulated in a membrane of inflammatory tissue, which surrounds the

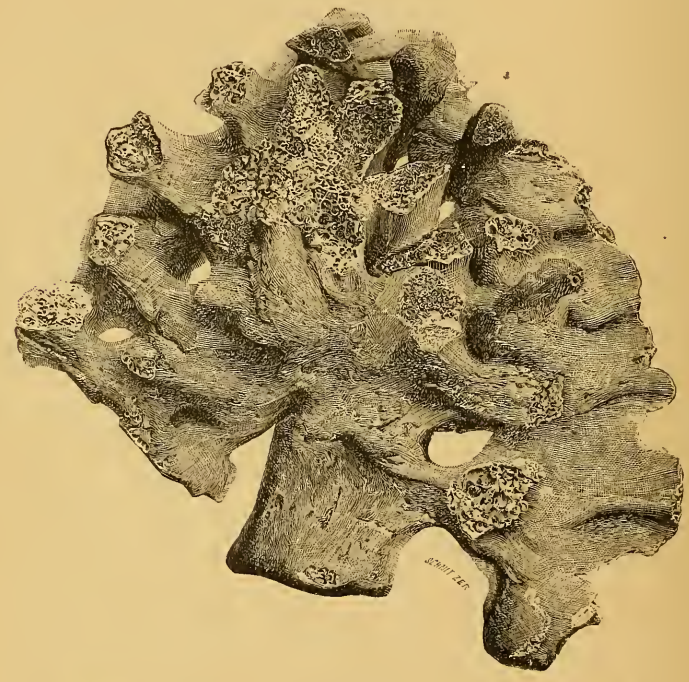

FIG. 1.—Pott's Disease Involving the whole Dorsal Region. Prehistoric Indian remains. (Peabody Museum, Spec. 17,223.)

focus, endeavoring to protect the surrounding healthy bone from the erosive action of the focus. Microscopical examination shows a mass of tubercles in a rarefied spongy bone tissue, and in the tubercles are to be found tubercle bacilli. From the fact that these characteristics are to be found in nearly all the specimens examined, the affection is spoken of as tuberculous ostitis.[1]

The focus of tuberculous material may either be absorbed or calcified, or, as happens much more commonly, the ostitis may increase until it has destroyed a large part or the whole of a vertebral body. In its

[1] Ridlon: Orth. Trans., vol. iv.

course of enlargement it may include portions of bone, the nutrition of which is cut off by the adjacent inflammatory destruction. Such portions necessarily become necrosed and with caseous matter, granulation tissue, and the products of inflammation constitute an area of altered and degenerated structure in the vertebral body. If this diseased area has become large enough, the vertebral body gradually becomes incapable of sustaining as much pressure as before. From the peculiar weight-bearing function of the vertebral column the pressure upon each vertebral body is always considerable when the vertebral column is in the erect position. If one vertebral body is becoming excavated, a point will be reached where it can no longer sustain the weight but must give way slowly or suddenly. A forward tilt of the whole vertebral column above the seat of disease is then inevitable, with a certain amount of backward angular deformity at the diseased vertebra. This is the mechanism of the production of the knuckle in the back. It is, in brief, a softening and crushing of one or more vertebral bodies, and a giving way of the column at that point as a necessary mechanical result.

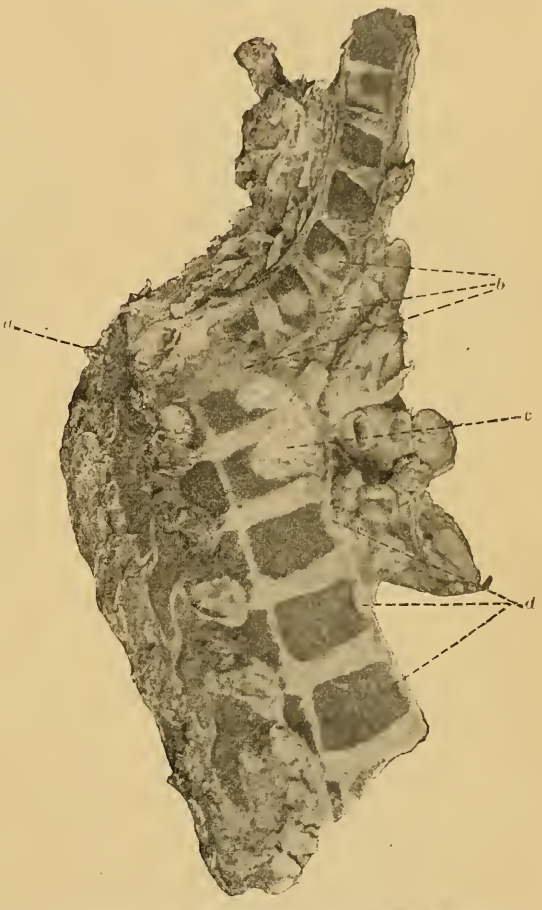

FIG. 2.—Tuberculosis of Cervical and Upper Dorsal Vertebræ. Tuberculous areas in anterior portion of eight vertebræ. Prevertebral ligament pushed forward opposite largest tuberculous area (beginning abscess). *a*, Knuckle; *b*, secondary tuberculous foci; *c*, primary focus; *d*, secondary tuberculous foci. (Nichols.)

This process is limited, as a rule, to the vertebral bodies; the transverse, articular, or spinous processes are rarely affected secondarily or primarily, their structure of hard bone apparently protecting them from tuberculous invasion.

There has been discussion as to the possibility of primary tuberculous disease of the intervertebral cartilage, some authorities affirming its impossibility, and denying the reliability of the pathological observations cited as proof to the contrary. The facts are, that the intervertebral cartilage between the diseased vertebræ becomes fibrillated and disintegrated and disappears, but that a very few cases have been reported by

FIG. 3.—Lower Dorsal Region. One intervertebral disc destroyed. Extension of process backward to dura and formed along prevertebral ligaments. Moderate knuckle hardened in upright position, so that gravity pressed diseased vertebræ together. *a*, Tuberculous softening. (Nichols).

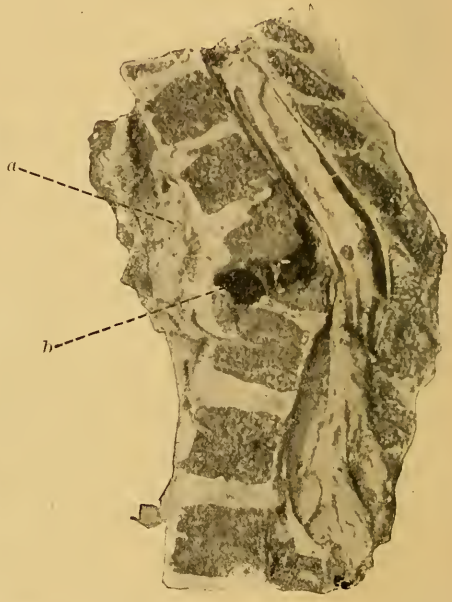

FIG. 4.—Lower Dorsal Region. Opposite half of specimen. Specimen rested on knuckle while hardening, so that gravity extended the spine. Marked separation of diseased vertebræ. *a*, Tuberculous disease beneath prevertebral ligaments; *b*, cavity between diseased vertebræ. (Nichols.)

reliable observers in which it would appear that the cartilage alone was affected. In the light of modern pathology these observations must be questioned.

Various portions of the vertebral bodies may be affected. There may be two or more foci in one vertebra, or the whole body may be equally affected; the disease may be limited to one spot, forming a localized abscess of the bone, or it may extend so as to involve the adjacent vertebræ. If the disease remains limited to the centre of the vertebra, but little deformity may result. Primary disease of two vertebral bodies in different, non-adjacent parts of the spine is rare. But an extensive destruction of two or more adjacent vertebræ from primary disease of one may be said to be the rule in Pott's disease. In some instances this destructive process may be limited to the surfaces of a large number of vertebral bodies; in others a few contiguous vertebral bodies are com-

pletely destroyed. The number of vertebræ involved necessarily varies; in some instances the bodies of twelve or even more have been destroyed, producing a deformity which involves almost the whole of the spinal

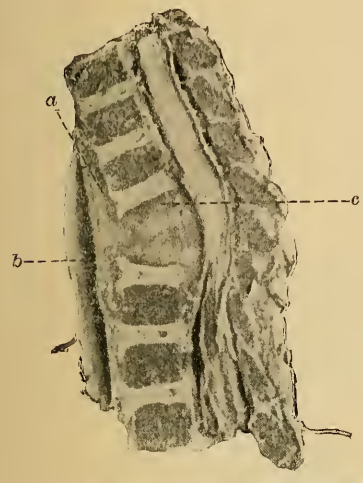

FIG. 5.—Tuberculosis of Lower Dorsal Region. Large area of tuberculous softening involving two vertebræ. Intervertebral disc destroyed. Process extends forward beneath prevertebral ligaments and pushes aorta forward. Process also extends backward to dura. *a*, Beginning abscess; *b*, aorta; *c*, tuberculous softening of vertebræ. (Nichols).

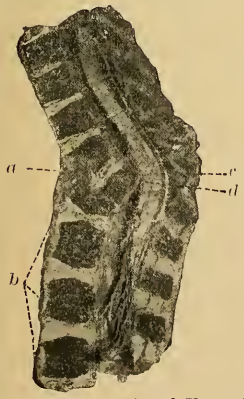

FIG. 6.—Lower Dorsal and Upper Lumbar. Tuberculous softening in anterior portion of bodies of five vertebræ. Marked knuckle. Portion of one vertebra pushed backward into spinal canal, but does not produce pressure upon spinal cord. *a*, Tuberculous disease of vertebra; *b*, tuberculous foci; *c*, cord; *d*, fragments of bone projecting into spinal canal. (Nichols.)

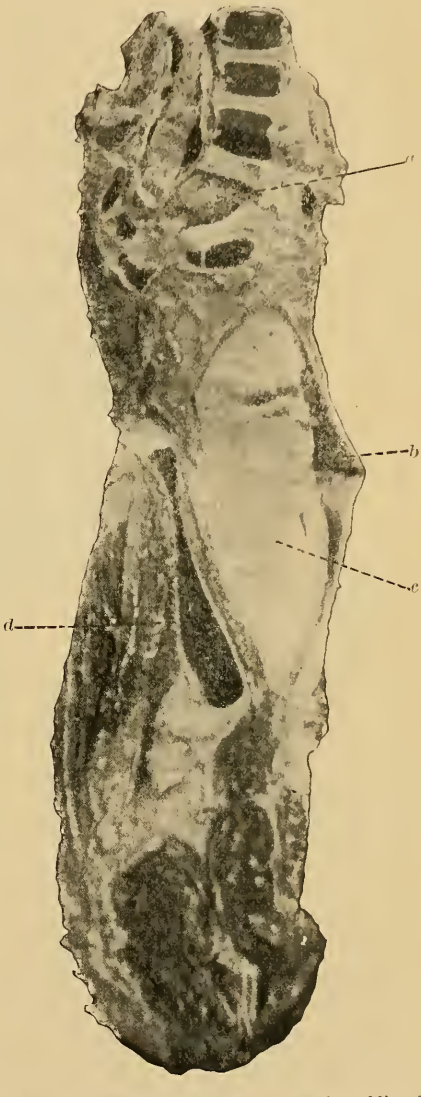

FIG. 7.—Lower Lumbar Region. Section obliquely through lumbar vertebræ and ilium in the line of the ilio-psoas muscle. Small tuberculous area in lowest lumbar vertebra. In pelvis is large tuberculous abscess in sheath of ilio-psoas muscle. *a*, Tuberculous focus in lumbar vertebræ; *b*, peritoneum and sheath of ilio-psoas; *c*, abscess; *d*, ilium. (Nichols.)

column. A superficial ostitis of the anterior surfaces of the bodies, without involving the intervertebral cartilages or impairing the weight-bearing function of the vertebræ, has been observed, though it is rare.

Abscess.—"In a considerable portion of cases of tubercular disease of the spine no abscess is recognized during life, but in cases seen at autopsy an abscess is almost invariably found, although it may be of small size. The tubercular material early pushes up the prevertebral ligaments and forms a flattened, soon a nodular swelling in front or sometimes to one side of the vertebræ. The contents of such a swelling are like the contents of other tuberculous abscesses" (Nichols).[1]

In certain cases the formation of tuberculous pus is a characteristic of the disease from the first, and in these cases abscesses are apt to be a

FIG. 8.—Spine, Lower Dorsal and Lumbar Region. Extreme knuckle. Lower ribs rest on pelvis. Change in angle of ribs due to continued deformity. Calibre of spinal canal not diminished. *a*, Knuckle; no narrowing of canal. (Nichols.)

conspicuous feature. The tuberculous pus finds its way, during or after the destruction of the body of the vertebra, into the surrounding tissues and gravitates downward. It appears usually in the course of the sheath of the psoas muscle when the disease is situated in the lower half of the spine, but the site of the abscess necessarily depends upon the place of the original disease, and may be in the mouth—as in retropharyngeal abscess—in the neck, in the axilla, or in the back, lungs, abdomen, or groin. The contents of such abscess as a rule contain no pyogenic bacteria.

Paralysis.—In certain cases meningitis and myelitis are present in

[1] Nichols: Orth. Trans., vol. xi., p. 391.

the cord opposite the seat of disease, accompanied sometimes by what is virtually the destruction of the cord at that point. The pathological condition of the spinal cord and its membranes in the paralysis accompanying Pott's disease of the spine has been extensively studied. It has been shown that the paralysis is very rarely caused by direct pressure of bone, as it is uncommon for even very marked deformities of the spine to narrow the spinal canal to any great extent. Moreover, paralysis sometimes occurs before there is any deformity, and it often recovers while the deformity gets worse. Many cases with extreme deformity are never paralyzed at all. In 52 cases collected from literature by Schmaus[1] in which autopsy afforded a chance of determining the cause of the paralysis, compression was mentioned as a cause in only 39 cases; in 33 of these a caseous pachymeningitis was noted. In 6 bony pressure existed, and in 5 of these the odontoid process of the axis was dislocated. In only 1 was kyphotic displacement the cause of the pressure. Kraske[2] estimates bony pressure as the cause in two per cent of the cases. Autopsy shows that in cases of paralysis the process ordinarily begins as an external pachymeningitis. The disease

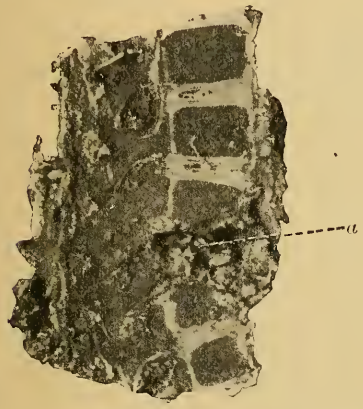

FIG. 9.—Lower Dorsal Region. Extensive tuberculous softening involving two vertebræ; intervertebral disc destroyed. Knuckle very slight, probably because the focus was in the centres of the vertebral bodies, and laterally destruction was not complete. *a*, Tuberculous cavity, involving centres of bodies of two vertebræ. (Nichols.)

FIG. 10.—*a*, Compressed cord, portion removed for examination; *b*, tuberculous dura; *c*, cauda. (Nichols.)

[1] Schmaus: "Die Compression-Myelitis der Caries," etc., Wiesbaden, 1890.

[2] Kraske: Archiv f. klin. Chir., vol. lxi.

of the vertebræ, by contiguity or by irritation, causes this meningitis, and there may be a deposit of inflammatory material in the dura, a consequent thickening of that membrane, and compression of the cord by this thickened dura at the point of irritation. Compression from thickened meninges must therefore be classed as one cause of paralysis. This meningitis is generally clearly tuberculous in character. Myelitis, or better, meningomyelitis, however, at times exists from an early stage in

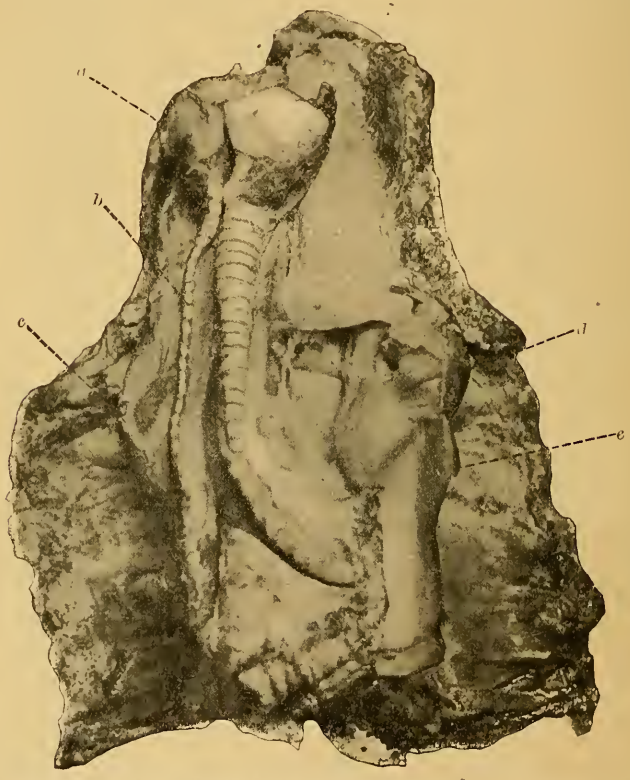

FIG. 11.—Tuberculosis of Lower Cervical and Upper Dorsal Regions; from Front. Trachea dislocated to right, large vessels to left, by large tuberculous abscess. *a*, Larynx; *b*, trachea laid open; *c*, wall of abscess; *d*, wall of abscess; *e*, aorta laid open. (Nichols.)

the cord itself. This is not to be demonstrated as tuberculous by the microscope. Oppenheim says of such processes: "We observe in syphilitic and tuberculous persons a form of myelitis which neither clinically nor anatomically can be considered specific, and yet it must stand in some relation to the infectious process."[1] This meningomyelitis is followed, if it is severe enough, by ascending and descending degenerations in the columns of the cord. Œdema also is present, at first apparently non-inflammatory in character but later inflammatory. This also must be a

[1] Oppenheim: "Lehrbuch der Nervenkrankheiten," p. 224.

factor in producing symptoms, and alone explains the immediate improvement in certain cases after forcible rectification of the deformity. Thrombosis and embolism of spinal vessels must be accounted as pos-

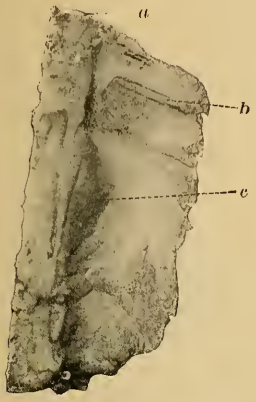

FIG. 12.—Spine (Dorsal Region) Cut in Vertical Antero-posterior Section. Only one-half of spine is shown. Early tuberculous spinal abscess projecting in front and to one side of spine. Seen from the front. *a*, Vertebral column; *b*, ribs; *c*, abscess. (Nichols.)

FIG. 13.—Spine Seen from Front. Mid-dorsal region. Portions of ribs attached. Small tuberculous abscess projecting on either side of the spinal column. *a*, Ribs; *b*, lateral abscess; *c*, lateral abscess. (Nichols.)

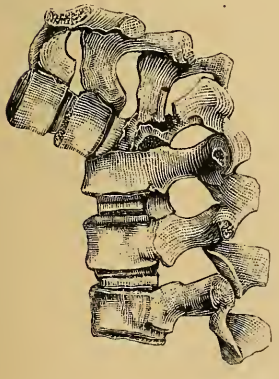

FIG. 14.—Complete Absorption of Vertebral Body. (Warren Museum.)

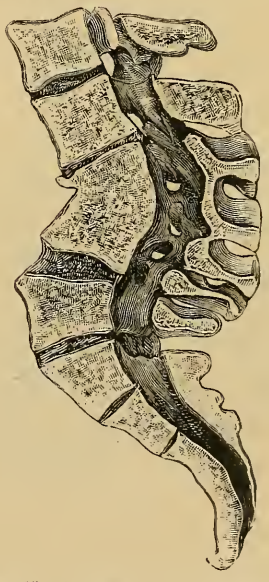

FIG. 15.—Complete Bony Ankylosis (Warren Museum.)

sible factors in contributing to the disturbance in the cord. The order of changes, as formulated by Schmaus, is as follows: œdema, diffuse softening, and sclerosis. If the myelitis ceases, it leaves a certain amount of sclerosis of the cord at the seat of the disease. This, again, may be

very slight, or the cord may be reduced to a fraction of its former size, and yet serve well enough to transmit healthy nervous impulses.

But meningitis and myelitis and œdema are not the only causes of compression myelitis in this disease, although the common ones. There may be a direct strangulation of the cord by the vertebral arches, obliterating the canal; or an abscess from diseased bone may be a source of pressure within the canal. A caseous deposit from the vertebræ and a loose piece of bone have been found as sources of pressure. The explanation of the paralysis by the assumption of a tuberculous myelitis of the cord is not compatible with the well-known tendency of the paralysis toward recovery.[1]

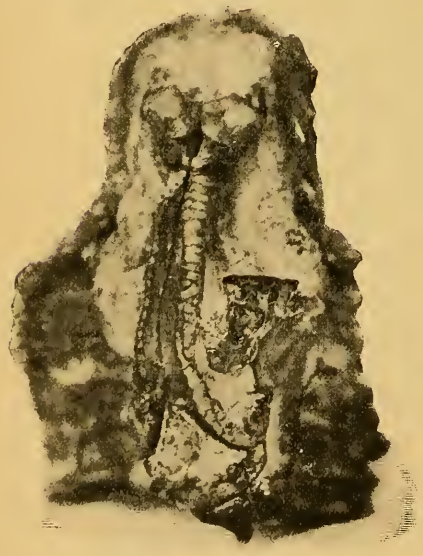

FIG. 16.—Abscess in High Dorsal Caries.

FIG. 17.—Distortion of Aorta. From a case of spinal caries in an adult. At one point marked constriction of the aorta. Angular deformity very marked. *a*, Constriction of aorta. (Copied from Dwight.)

In proportion to the extent of the disease and the number of vertebræ involved, an angular deformity of the spine may be present to any extent.[2] In severe cases this angular deformity leads to many secondary pathological changes. The shape and capacity of the chest are necessarily very much

[1] Spiller: Johns Hopkins Hosp. Bull., June, 1898.
[2] Bouchacourt: Rev. d'Orth., May, 1895.

altered, and the ribs sometimes sink into the pelvis. As a result of these changes in chest capacity, hypertrophy of the heart, often accompanied by valvular disease, is common. In examining thirty one post-mortem specimens of Pott's disease in adults, Neidert[1] found hypertrophy of the heart in twenty-four, muscular degeneration of the walls of the heart in four, and mitral stenosis in two. The aorta may be distorted as a result of the deformity. Thomas Dwight reports a case in which its course "might be compared to an S lying on its side, with the ends bent strongly back to fit around the prominence of the spine."[2] Lannelongue[3] found a very marked narrowing of the calibre of the aorta in many cases. Sometimes it was reduced even to a mere slit.

A cure, however, is possible even in cases with very advanced deformity. This cure can come about in one of two ways: (1) By ankylosis between the surfaces of the bodies of the diseased vertebræ—a very slow process, which requires years for its completion; (2) by the deposit of bone in the inflammatory material, thrown out around the column and by the action of the formative ostitis which accompanies the destructive process, the vertebral column is supported, as it were, in surrounding bone.

Occurrence and Etiology.

Sex.—Sex does not appear to be an important factor in causing Pott's disease, though statistics vary somewhat. Gibney found in 2,455 cases, 1,329 males and 1,126 females. Mohr found females slightly more numerous than males. Fisher, in 500 cases, found 261 males and 239 females. Taylor in 412 cases found 234 boys and 177 girls. Of 294 cases treated at the Children's Hospital there were 152 boys and 142 girls. Vulpius[4] in 810 cases found 53 per cent of males.

Age.—The disease is more common in childhood. Mohr found, in 72 cases, that the disease occurred between the first and fifth years in 29 per cent; between the sixth and tenth years in 22 per cent; between the eleventh and fifteenth years in 22 per cent; between the sixteenth and twentieth years in 16 per cent; and above the twentieth year in 11 per cent. Drachman found in 161 cases 41 per cent between one and five years, and 36 per cent between five and ten years. The oldest patient was seventy-seven years of age, and the youngest eight weeks. Gibney found that 87 per cent were under fourteen years of age; 7 per cent between fourteen and twenty; and 4 per cent over twenty-one. Taylor found in 375 cases that 226 were under five; 68 between five and ten; and 24 between ten and fifteen.[5]

---

[1] Neidert: Inaug. Diss., Munich. 1886.

[2] Dwight: Amer. Jour. Med. Sciences. January, 1897.

[3] Rev. de Chir., August 10th, 1886, p 671.

[4] Archiv f. klin. Chir., Bd. lviii., Hft. 2.

[5] New York Med. Record. August 13th. 1881.

Localization.—Any of the vertebræ may be attacked, but in varying frequency. Statistics are of uncertain value, as they are chiefly based upon autopsies, and therefore are most commonly from adults. Mohr, in 56 autopsies of caries of the spine, found that the disease is most common in the thoracic region (33 in 56 cases), next in the lumbar region (27 times), and next in the neck (12 times). The sacrum was diseased in 1 case. As there are more dorsal vertebræ than either cervical or lumbar, it is natural that the number of cases of dorsal disease should be greater than in the other regions. Dollinger in 538 cases determined the vertebræ originally affected to be as follows: cervical, 63; dorsal, 321; lumbar, 154. The most frequent seat was between the twelfth dorsal and first lumbar. The twelfth dorsal was affected 64 times, the first lumbar 59 times, and both 123 times. The upper half of the column was affected primarily only 117 times.

Taylor found in an examination of three hundred living patients with Pott's disease that the points of greatest liability to the disease are first, the sixth and the seventh cervical; second, near the eighth dorsal; third, the second and the third lumbar. The points of least liability to the disease are from the first to the fourth dorsal and the eleventh and the twelfth dorsal, besides the two extremities of the spinal column. Although, as is seen, the locations of relative frequency given by the different observers do not agree, it would appear that certain portions of the spine are more liable to attack than certain others, and that the theory advanced by Taylor was a plausible one—viz., that the regions most liable to the disease were those which were the most exposed to jars or increased pressure; and that the disease would be more frequent where the hinges of motion at the spinal column came, varying to a degree according to age and occupation, or where there was the greatest exposure to the effects of violent jars.

Causation.—It may thus be assumed that the localizing cause of Pott's disease is jar or superincumbent pressure; the influential cause that physical state which is incapable of resisting slight trauma, exposing the tissue probably to the invasion of the tubercle bacillus.

Gibney, in an examination of 185 cases, found a hereditary tuberculous taint in 76 per cent. In 45 per cent a weakened condition from previous sickness was found; and in 22 per cent both an inherited and an acquired diathesis were found. Taylor, in 845 cases, found 53 per cent with a history of preceding trauma (Vulpius in 810 cases found the same percentage [53]); in 15 per cent there was disease of the lungs in nearer or more distant relatives; in 19 per cent so-called scrofula was asserted, and in 34 per cent a sickly condition. Vulpius found a history of hereditary tuberculosis in 16 per cent of his 810 cases.

Symptoms.

Few affections have a clinical history which varies so widely and appears under such different guises as that of Pott's disease. The one constant symptom, however, which accompanies all cases of Pott's disease and must often form the chief reliance in diagnosis is muscular rigidity at the affected portion of the spine. Just as spasm of the joint muscles is the constant symptom of chronic joint disease, so is restricted motion between the diseased vertebræ the constant accompaniment of Pott's disease, in its early or later stages.

Typical cases of Pott's disease are so characteristic in their symptoms that the diagnosis is evident almost at a glance. The guarded character of all the movements is perhaps the most striking feature. In walking, in stooping, or in lying down, the spine is most carefully guarded against jar and against motion, attitudes are assumed which relieve the vertebral column of some of the weight of the body, and a glance at the naked child shows unnatural modes of standing and walking.

A prominence of the vertebræ is ordinarily present as early as at this stage, and oftener than not pain is acute and aggravated by motion. Constitutional disturbance is also very likely to be present when the disease has been of even a few weeks' duration. Loss of flesh and appetite and inability to go about much without fatigue are often among the first symptoms to attract attention.

Peculiarity of attitude and gait, muscular stiffness, and referred pain are the most prominent of the earlier symptoms, and they may be present before a projection has been noticed. The importance of recognizing these early symptoms can hardly be overstated, as it is on an early recognition of the affection that the hope of a ready cure is to be based.

Attitude.—The peculiarity in attitude noticed early in the disease is due either to reflex muscular spasm—similar to that seen in joint disease—or to an unconscious effort on the part of the patient to prevent jar or any increased pressure upon the affected vertebral bodies. These attitudes necessarily vary according to the point of the spine attacked. In disease of the upper cervical region, the most common attitude is that of wry-neck.

When the disease is in the lower cervical or upper dorsal region, the chin is held somewhat raised, to balance the weight of the head on the articular facets, suggesting the position of a seal's head when out of water. The spinal column below the point of disease is abnormally straight, and in some instances curved slightly forward, while in the lower dorsal region an exaggerated backward projection of the spinous processes may be seen; this projection, due to a compensating curve, is

sometimes so marked as to suggest that the disease has attacked another part of the spine.

In the middle dorsal region the attitude to be noticed most frequently

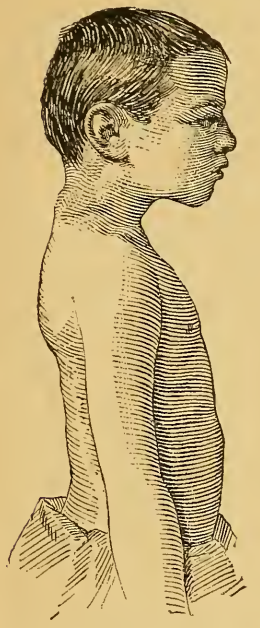

FIG. 18.—Attitude in Cervical Caries of only Moderate Severity.

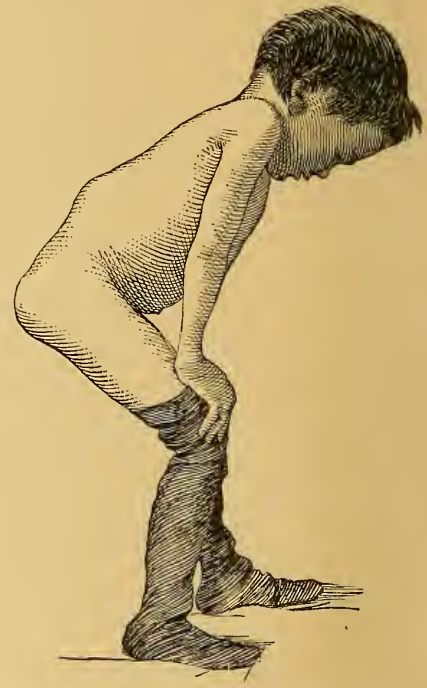

Fig. 20.—Attitude Assumed by Children with Acute Pott's Disease, and in Other Cases Necessitated by Psoas Contraction.

FIG. 19.—An Occasional Attitude Assumed in Acute Pott's Disease, Especially when the Disease is in the Cervical Region.

FIG. 21.—Attitude in Severe Pott's Disease with Psoas Contraction.

is an elevation of the shoulders. Temporarily a slight lateral deviation of the spine is to be seen. In the lumbar region, the patients in the early stage frequently will be noticed to lean backward, like pregnant women or adults with large abdomens. A peculiar position and characteristic sidling gait, which is sometimes seen at a comparatively early stage of disease in the lower dorsal or lumbar region, is due to a slight contraction of the psoas and iliacus muscles.

In a late stage, when psoas abscess is present, a marked contraction of these muscles takes place; but even when there is no evidence of ex-

FIG. 22.—Severe Grade of Psoas Contraction.

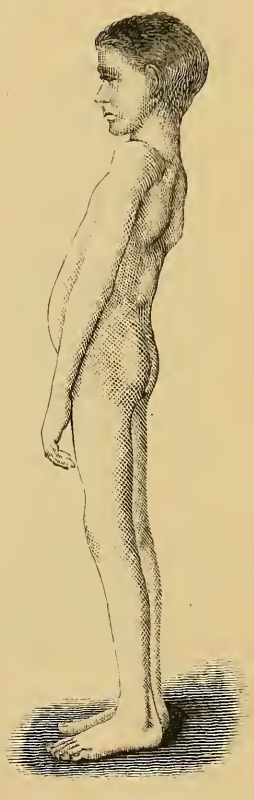

FIG. 23.—Lordosis in Lumbar Pott's Disease.

istence of suppuration or of a psoas abscess, slight inflammatory irritation of the muscles will produce a limitation to the arc of extension of the thigh on the trunk.

In general, in addition to the square position of the shoulders, the peculiar position of the head, and the erect attitude of the upper part of the spine, which prevents the superincumbent weight of the trunk and upper extremities (above the diseased portion of the spine) from falling forward upon the diseased vertebral body, the gait is peculiar; the pa-

tient walks more on the toes than on the heels, and with the knees slightly bent—in such a way that all possible springs may be brought into play to diminish jarring the spine.

These peculiarities of attitude and position vary in severity according to the acuteness of the disease; they may be at one time more noticeable than at another. Characteristic also at this stage of the disease is a muscular stiffness, which becomes more marked after the patient has been quiet for a while (during sleep). The stiffness of the limbs diminishes or disappears after the patient has moved about. A certain amount of muscular rigidity of the muscles of the back will be felt on pal-

FIG. 24.—Lateral Deviation of Spine in Dorsal Pott's Disease. Front view.

FIG. 25.—Lateral Deviation of the Spine in Dorsal Pott's Disease. Back view.

pation in affections of the middle dorsal and lumbar regions; stooping which involves arching of the back forward is difficult or impossible in disease of the lower spine, and in attempting to stoop in order to pick up any article from the floor the patient will keep the spine erect and reach the floor, lowering himself with an erect trunk, by bending the knees.

It will often be noticed that children become tired more easily than usual, and after playing about for a time will desire to lie down, to rest their arms upon a chair or seat, or to support the head with their hands, or the trunk by holding on to the thighs, according to the part of the spine affected.

The amount of muscular stiffness, rigidity, and difficulty in maintaining the spine erect is in a measure an index of the degree of activity of the disease. In early cases the muscles on either side of the area of the affected vertebræ will often, on bending the back, be seen to spring out in relief, acting like physiological splints to the diseased vertebral column.

Various modifications of characteristic attitudes are at times produced. The most common of these probably is the flexion of the thigh which re-

Fig. 26.—Lateral Deviation of Spine in Lumbar Pott's Disease.

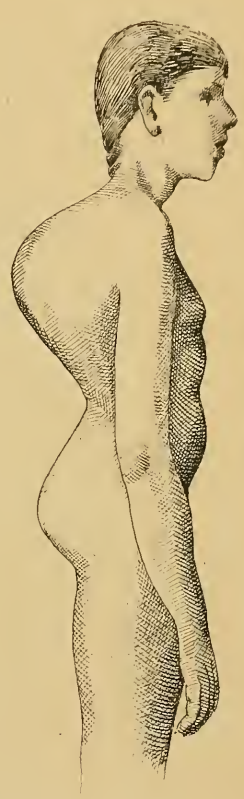

Fig. 27.—Rounded Outline of Deformity as Seen in Cured or Convalescent Pott's Disease.

sults from psoas contraction, usually the result of psoas abscess. The contraction of the muscle is both the warning and the accompaniment of the abscess. It may be present to such a degree that the leg cannot be put to the ground in walking and the use of a crutch is necessitated.

Lateral deviation of the spine is an attitude to be found in Pott's disease and is discussed in its relation to lateral curvature under the head of

diagnosis. As a rule the lateral curve of Pott's disease is characterized by very slight, if any, rotation of the spinal column on a vertical axis.[1]

The lateral deviation has no especial significance except in indicating a certain modification of treatment to be considered later. It is most severe in acute cases. The divergence may reach 8° from the perpendicular at its maximum point,[2] and in thirty cases measured by the writers did not exceed this, 5° makes a divergence enough in amount to make the fitting of apparatus difficult. This divergence is diminished by the recumbent position. It is sometimes the first symptom of Pott's disease, and one which has attracted but little attention.

Pain.—In certain cases of Pott's disease pain is absent altogether, but it is often present to a most distressing degree, and it forms a more prominent symptom than it does in hip disease or tumor albus, for instance. In a measure it tends to mislead both parents and physician, for the pain is rarely complained of in the back, but is referred to the peripheral ends of the nerves, and is thus described as being felt in the abdomen, chest, or limbs. Chipault has described a class of cases in which severe pain in the kyphus is present, and has given to the condition the name "apophysalgie Pottique."[3] Abdominal pain passes for "stomach-ache," and pains in the limbs for "growing pain" or rheumatism. In general, it may be said here that persistent localized pain in the case of a child is a symptom demanding very great attention.

The sleep of these children is apt to be much disturbed by pain, for the suffering from Pott's disease, like all the pain of bone diseases, is more severe at night. In the milder cases this is manifested by simple restlessness, while in more severe cases it takes the form of crying spells. This may even be the case when the children can walk about without pain during the day. As a rule the pain is aggravated by exercise, jars, and wrenches. It is not always elicited by pushing down on the child's head. Superficial sensitiveness over the spinous processes is not a symptom of Pott's disease.

The pain is usually subacute, and may be only occasional. At times the attack may be very severe, accompanied by intense hyperæsthesia, so that the pressure of the bedclothes cannot be tolerated, and patients in this condition have been supposed to have intense peritonitis or pleurisy. The subacute form is more common, and this, together with muscular stiffness, often gives rise to a diagnosis of rheumatism, sciatica, or neuralgia. Analogous to these attacks of pain are disturbances of the functions of other nerves—manifested in cough, a peculiar grunting respiration, dyspnœa with cyanosis, gastric disorders, obstinate and recurring vomiting, and troubles of the bladder, with or without pain at

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[1] Annals of Surgery, July, 1889. [2] Orth. Trans., iii., 182.
[3] "Trav. de Neurologie Chir.," 1898.

the end of the penis. Patients suffering in this way have been treated for bronchitis, pneumonia, gastritis, or cystitis. In one notable instance the operation for stone in the bladder—lateral cystotomy—was performed. No vesical trouble was discovered, but at the autopsy disease of the lumbar vertebræ was found.

These periods of suffering may become intense—constituting acute attacks, subsiding after rest, and recurring at intervals without apparent exciting cause.

Eye symptoms may exist in Pott's disease. Partial dilatation existed in thirty-six out of thirty-eight cases reported by Bull, and neuritis and optic atrophy have been reported.[1]

It is to be expected that pain will be diminished and generally controlled by efficient mechanical treatment. Certain cases, however, are from the first so intractable that pain persists in spite of all that can be done. Fortunately such cases are not the rule, and in general it may be assumed, when pain comes on in the course of treatment, that the apparatus does not fit, if mechanical treatment is used, or that the parents are not careful in the nursing of the child or in carrying out treatment thoroughly. In a few instances it will be found that pain cannot for a time be entirely checked by treatment. A sudden and violent increase of pain should lead one to suspect an approaching access of the disease—with increase of the deformity—the formation of an abscess, or the beginning of paralysis. In cases in which recovery from Pott's disease has occurred with great deformity the lower ribs may have sunk below the crest of the ilium, and by rubbing against it may cause severe pain.

FIG. 28.—Sharp Angle of the Acute Stage.

Deformity.—The most characteristic feature of Pott's disease is the deformity—that is, the projection backward of one or more spinous processes. This is occasioned by the destruction of the vertebral bodies.

[1] Knies: "Das Sehorgan und seine Erkrankungen," 1893, p. 205.

The projection is primarily of the vertebræ first affected, but following this other vertebræ are more or less involved, and the curve increases, with the establishment of secondary curves. The sharper the projection, as a rule, the more acute is the process; but this rule, however true in the upper dorsal region, has occasional exceptions in the lower dorsal and upper lumbar regions. It may be stated that in old cases there is, as a rule, more of a curve and less of an angle. It is not absolutely true that the greater the amount of the disease the greater the deformity, for there may be extensive disease on the front of several

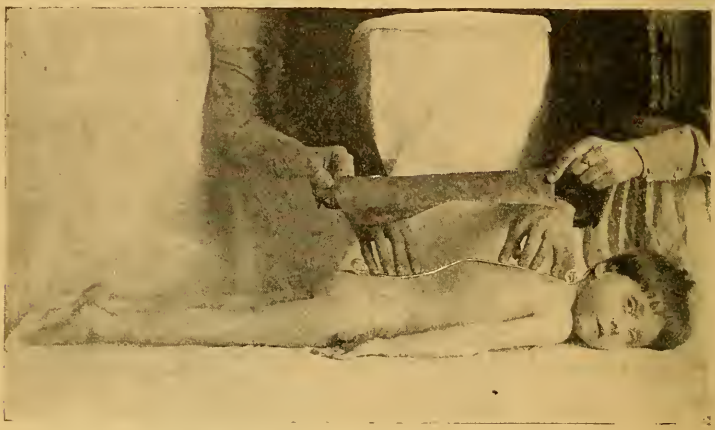

FIG. 29.—Method of Measuring Deformity in Pott's Disease. (Children's Hospital Report.)

bodies without diminishing the weight-bearing function of all of them; but, generally, the more vertebræ involved, the greater is the projection.

It is most important to keep a record of the deformity in each case under observation. This record is most easily taken by a simple method.

A strip of sheet lead half an inch wide, of the quality known to the dealers as "four pounds to the foot," is made straight by pressing out the curves, and is laid along the spinous processes of the child, who lies on his face on a flat table without a pillow, with his hands at his sides, and his head turned to one side. With the fingers the lead is pressed against the spinous processes, and when it is removed it is stiff enough to keep its shape. The curve is then drawn upon a piece of cardboard by means of this lead strip, placed on its side and used as a ruler. The cardboard curve is cut out with scissors and the concavity is then applied to the child's back to see if it fits accurately. If not, it should be trimmed with the scissors until it does. The slightest change in the outline of the back can then be detected at any subsequent visit, because any increase or diminution of the deformity will cause the cardboard cutting to fit the outline of the back imperfectly.

If the deformity is left to itself, its tendency is to increase until a

spontaneous cure results or death ensues. In many cases in dorsal Pott's disease this result is reached only after an enormous deformity has occurred. In cervical and lumbar Pott's disease spontaneous cure is more likely to occur, and, when it occurs, is accompanied by much less deformity than in the dorsal region.

When this spontaneous cure occurs, the change takes place gradually and does not cause narrowing of the spinal canal. The gibbosity is most marked in disease of the upper dorsal region; the curve in the lumbar region is an arc with a longer radius than is found elsewhere in the spine. The secondary curvatures are: in cervical Pott's disease, a dorsal incurvation below the disease, with a slight lumbar excurvation; in dorsal disease, an increased

FIG. 30. – Depression of the Sternum in Dorsal Pott's Disease.

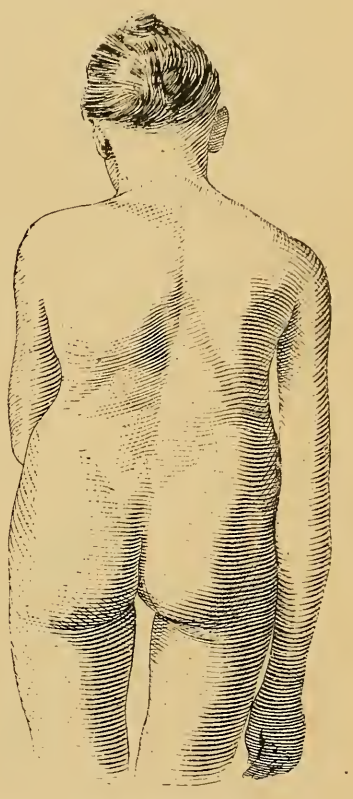

FIG. 31.—Showing Shortening of Trunk in Pott's Disease of Moderate Grade.

hollowing in above and below the gibbosity of the disease; in lumbar disease, a long curvature with convexity inward above the disease. The neck becomes shortened and thickened in cervical Pott's disease; the trunk is shortened in disease of other parts of the spine; there is also in cases of long duration a diminution of an uncertain origin in the growth of the whole body, so that adults recovered from Pott's disease of ordinary severity are usually of less than average height. In severe cases the limbs more usually grow nearer to the normal amount, and are necessarily out of proportion to the length of the trunk.

Taylor[1] has formulated the retardation of growth in patients with Pott's disease as follows:

"Disease of the cervical region is least harmful in this regard; disease of the dorsal, especially the lower half, the most so, while disease of the lumbar region occupies an intermediate position. An average growth of an inch to an inch and a half, extending over a number of years, instead of the normal two inches and upward, is fairly satisfactory for patients under treatment or soon after the active stage of the disease. A growth of one and one-half to two inches for a similar period indicates that disease is arrested or is retrogressive; in other words, that the case is doing well. Very slow or absent growth indicates progressive disease or impaired vitality. Intercurrent disease or too long absence from surgical supervision is often followed by a diminution of the growth rate."

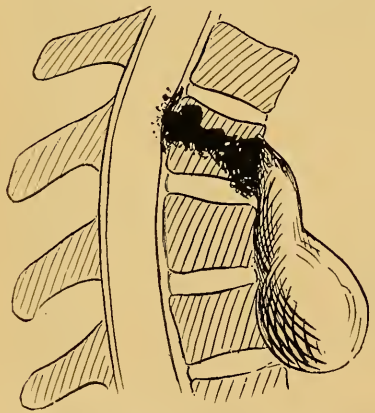

FIG. 32.—Diagram of Abscess from Pott's Disease.

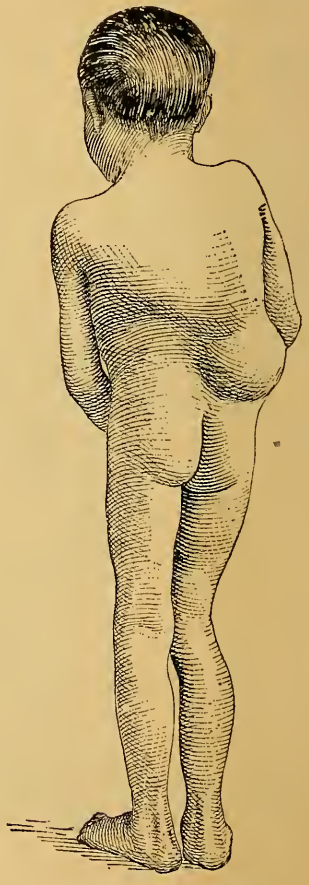

FIG. 33.—Lumbar Abscess.

An alteration in the shape of the lower part of the face takes place in marked dorsal disease, with a facial expression which is characteristic.

Cases in which the deformity is rapidly increasing are as a rule characterized by much pain.

Deformity of the chest is a constant accompaniment of dorsal Pott's disease. The vertebral column cannot give way and form an angular deformity without altering the position of the sternum and ribs. The de-

[1] H. L. Taylor: Transactions of the American Orthopedic Association, xi., p. 197.

formity is usually a thrusting downward and forward of the sternum with a lateral flattening of the chest. In short, it results in the formation of a pigeon-breast. There may, however, be a prominence of the ribs on both sides of the sternum, where a depression of the sternum is seen. Sometimes the pigeon-breast is the first symptom to attract the attention of the parents, and for that alone the children are brought to the surgeon.

High temperature is generally present in the afternoon in cases under ambulatory treatment. This temperature is diminished or often reduced to normal in cases under bed treatment. The rise of temperature is from one to three degrees in average cases and occurs independently of abscesses. This statement rests on ten hundred and fifty observations made at the surgical out-patient department of the Children's Hospital.[1]

General Condition.—Pott's disease produces a more profound impression upon the general condition than do the other tuberculous joint and bone diseases. These children are frequently fretful and capricious, made so either by the disease and by ill-health or by injudicious petting on the part of the family. They are also often precocious and their mental development is superior to that of healthy children of the same age. They are, moreover, delicate, take cold easily, and seem especially liable to slight attacks of pneumonia. Patients with Pott's disease are of course liable to attacks of tuberculous meningitis, but the experience of the writers would lead them to believe that the liability to this was less than in hip-joint disease. Necrosis of the ribs is one of the more uncommon complications.

Complications.

Paralysis.—Partial or complete paralysis of the legs is a frequent complication of Pott's disease. It may occur in early or late, in mild or severe cases, and no apparent exciting cause can be assigned for its appearance.

The clinical picture is what one would expect from a consideration of the pathological condition; a paralysis of motion mild or severe, followed, if the case gets worse, by more or less paralysis of sensation. The motor paralysis varies from mere muscular weakness to complete loss of power. It begins as a sense of fatigue, a dragging of the feet; then there is inability to hold one's self erect. Unless the disease is in the lumbar region, the reflexes are exaggerated, and muscular spasms may start from the least irritation; they frequently appear spontaneously. In severe cases the muscles are flaccid and the legs may be powerless. With the secondary degenerations in the cord rigidity sets in. The bladder and rectum are paralyzed toward the end of all very bad cases, and whenever

[1] Amer. Jour. Med. Sciences, December, 1891.

the lumbar enlargement is involved; in milder cases they escape. The arms are paralyzed in certain instances of dorsal Pott's disease. Of the sensory paralysis below the lesion there is less to be said; it is apt to begin as paræsthesia; anæsthesia afterward may come on to a greater or less extent. Trophic disturbances are not to be seen unless in exceptional cases.

The wasting of the muscles and diminution of electric contractility are usually only such as disuse would cause.

In a few instances affections of the joints, supposed to be secondary to lesions of the cord, have been noted, and instances are mentioned in which herpes zoster, apparently due to the same cause, was present.

Many patients with Pott's disease, especially children, are bedridden, or at least unable to go about, without being paralyzed. In these cases the reflexes should be normal. When the disease runs its course unchecked, asthenia is often profound, and although there may be no trace of paralysis, the patient frequently has no desire or strength to walk or even to sit up. Another cause which sometimes keeps patients off their feet, independently of paralysis, is psoas contraction of a severe grade, especially if it be bilateral. Still another reason is a preponderating mental impression of inability to walk or stand. Many patients persist in walking when paralyzed to a degree which ought to preclude it, and which would ordinarily do so, while others are bedridden with little or no paralysis, or remain so after the paralysis has totally disappeared, having recovered without being conscious of restoration. This accounts for the suddenness of invasion, and particularly of recovery, in some of these paralyzed cases.

Paralysis is rarely an early symptom in Pott's disease, though it has been observed before the stage of deformity. The frequency of paralysis is indicated by the figures collected by Gibney. Among 295 patients with caries of the spine, paralysis was noted 62 times; in 189 cases of caries of the upper dorsal and cervical region, paralysis occurred in 59; in 106 cases of lower dorsal and lumbar disease, paralysis occurred in only 3. In 700 cases observed by Dollinger, 41 cases of paralysis were noted; 4 of these were in the cervical and 37 in the dorsal region. In 26 of the 41 cases the disease involved the region from the third to the seventh dorsal vertebræ inclusive.

Paralysis is usually bilateral; it may, however, be unilateral, and in some unusual instances it occurs above the point of deformity. Taylor and Lovett[1] found in an examination of 59 cases of paralysis (out of 445 cases of Pott's disease) that the location of disease was as follows: 1 cervical, 7 cervico-dorsal, 37 dorsal, 7 dorso-lumbar, 4 lumbar, 3 unclassified. The deformity was large in 20, medium in 10, small in 17 (in 12

[1] Med. Rec., 1886, xxix, 699.

unclassified). The paralyzed cases presented no worse deformity than that seen in average cases. In 26 the outline of the deformity was rounded and gradual; in 116 it was distinctly sharp. The paralysis occurred on the average about two years after the beginning of the disease. It came on immediately after a fall in 4 cases. The duration of the paralysis was never, in the cases reported, over three years, except in one case, when it persisted with but little improvement for six years; in 2 cases it lasted three years; in 5 cases it lasted two years. A recurrence of the paralysis was noted in 6 cases, 4 having two attacks and 2 having three. Recurrence is not an unusual feature in its history. Out of 72 cases of caries of the spine watched by Mohr, there was paralysis in seven per cent.

Paralysis is an affection of rare occurrence in Pott's disease under efficient protective treatment. Its prognosis is extremely favorable in mild cases, or in severe ones if they can be treated early. Recovery, when it occurs, is generally complete, leaving no trace of the disability of the limbs. Incomplete recovery is uncommon, but incomplete paralysis often is present. In fact the early commencement of efficient treatment will often seem to render abortive an attack of paraplegia, and change what threatened to be a complete loss of power to a comparatively trifling disability which is merely enough to prevent walking for a few weeks or months.

Abscess.—In most cases of Pott's disease, especially in those under efficient treatment, the whole course is run without any evidence of suppuration, but in others abscesses form a distressing complication.

The earlier treatment is begun and the more efficiently it is carried out, the less liable are abscesses to form; but it must not be assumed that the occurrence of abscesses is evidence of incomplete treatment. In certain cases of severe disease an abscess cannot be avoided.

FIG. 34.—Retropharyngeal Abscess, showing Characteristic Expression and Attitude.

The causes of the development of an abscess are the same in Pott's disease as in bone tuberculosis elsewhere. What the abscess-determining influences are, which in some instances give rise to profuse suppuration, and the absence of which in other cases allows immunity, is at present

conjectural. They may be supposed to be dependent on the amount of constitutional or local power of resistance on the part of the patient; the extent of the bacillary invasion; the severity of a previous injury; and the individual degree of recuperative power, or of reparative tissue development. If we consider the situation of the vertebral bodies (the point of origin of abscesses)—projecting into the cavities of the thorax and abdomen, surrounded by the lungs and intestines, close to the large vessels and the œsophagus—it will seem extraordinary that the formation of an abscess does not more frequently lead to a fatal termination. In fact, however, the fluid contents of the abscesses follow in the line of least resistance, and the layers of fasciæ, in most cases, protect the larger cavities of the trunk from invasion; the pus generally extends to the surface at points distant from its origin, appearing in the neck, in the lumbar region, in the groin, or in Scarpa's triangle. Treves' table shows the anatomical conditions affecting the course of abscesses.

Variety.	Course.	Exit.
Cervical.	*a.* Anterior.	Into posterior walls of pharynx.
	b. Burrow beneath deep fascia into thorax as mediastinal abscess.	Into trachea, œsophagus, or through an intercostal space.
	c. Laterally between the longus colli and scaleni muscles.	Posterior to the sterno-cleido-mastoid.
Dorsal.	*a.* Burrow posteriorly.	On the back or side a short distance from the spine.
	b. Within psoas sheath.	Beneath Poupart's ligament in Scarpa's triangle.
Lumbar.	*a.* Enter psoas sheath.	As psoas abscess.
	b. Burrow between the fasciæ of the quadratus lumborum and abdominal muscles, through the internal oblique.	Posteriorly beneath the external oblique and latissimus dorsi at the outer border of the erector spinæ muscle.
	c. Gravitate beneath the internal iliac muscles over the posterior brim of the pelvis, perforating the great sacro-sciatic foramen.	As gluteal abscess.
	d. May be directed to the iliac region along the aorta and external iliac arteries.	As gluteal abscess.

Of these psoas abscess is the most common. It is very rarely met with in children unless in connection with vertebral disease, but in general it is an almost pathognomonic sign of dorsal or lumbar Pott's disease.

The abscess tends to enlarge more on its outer than on its inner side because the fascia is less resistant there. It finally reaches Poupart's ligament and bulges in the groin. The pus may, however, travel as far

down as the insertion of the psoas muscle. There is then a swelling both above and below Poupart's ligament, and fluctuation may be detected between the two by placing one finger above the ligament and the other below it.

Pus may find its way to the iliac fossa either from a psoas abscess or by finding its own way there directly from the diseased bodies. At times a collection of pus will work over the crest of the ilium or through the sacro-sciatic foramen and point in the gluteal region.

A lumbar abscess is the outcome of disease of the lumbar vertebræ.

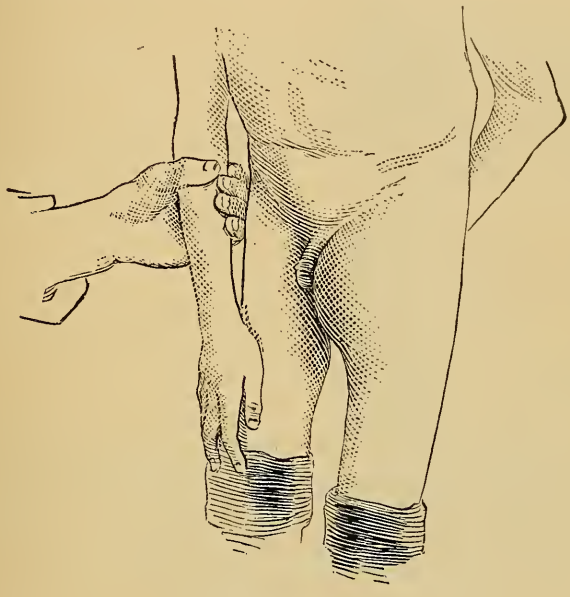

FIG. 35.—Psoas Abscess.

It appears as a swelling in the loin on one side or the other just outside the quadratus lumborum. At times it is associated with dorsal caries and not with lumbar.

Abscesses may accumulate in the inguinal region above Poupart's ligament, simulating hernia. Before passing down the sheath of the psoas muscle, they may enlarge in the abdominal cavity beneath the peritoneum, constituting a layer of subperitoneal abscesses. In time these abscesses descend down the thigh, but they may remain for a long time large, threatening, abdominal tumors.

Dollinger, in 700 cases of Pott's disease observed, found 154 abscesses. Of cervical cases 20.6 per cent resulted in abscess, of dorsal cases 11.6 per cent, and of lumbar cases 40.1 per cent. In the 154 abscesses there were 13 cervical, 47 dorsal, and 94 lumbar. R. W. Parker in dorsal

cases found 8 per cent of suppuration, in dorso-lumbar 30 per cent, and in lumbar cases 70 per cent.

Abscesses, however, at times point in all sorts of places. They may burst into the mouth, trachea, bronchi,[1] mediastinum, œsophagus, or pleura. They may rupture into the intestines, bladder, vagina, rectum, or the abdominal cavity; and one case is reported in which a spinal abscess simulated a fistula in ano. Abscesses may also burst into the spinal canal or the hip-joint. Occasionally they burst in the alimentary canal, not so rarely in the lungs, and exceptionally in the peritoneum or larger vessels. Sometimes apparently the sac descends on both sides of the spinal column, developing two abscesses.

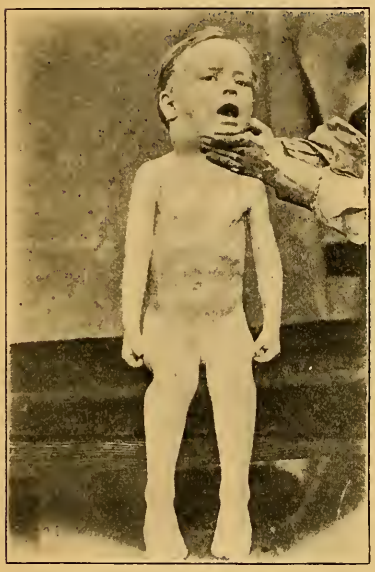

Fig. 36.—Cervical Abscess.

The local symptoms presented by abscesses vary with the locality. Retropharyngeal abscesses cause dyspnœa and dysphagia. Abscesses in the lung give rise to less disturbance than would be supposed; in reality they present the rational and physical signs of a low form of localized pneumonia, of a chronic or subacute type. The bursting of an abscess into the bronchi is characterized by the discharge of a large quantity of pus, which is coughed up, the amount of dyspnœa, collapse, and danger from suffocation being dependent on the size of the abscess. The sudden discharge of pus is the indication of rupture into the œsophagus, intestines, and bladder; rupture into the vessels will necessarily be fatal, and there are no symptoms which will give warning of the impending danger.

The course of an abscess is toward absorption or increase. It may remain stationary in size, and quiescent for a long time—a condition of things which may be compatible with fair general health. Instances are not uncommon in which adults have been able to attend to active work and children to play about, although suffering from large cold abscesses.

When absorption takes place the fluid contents disappear, and the caseous and purulent detritus, if present, in all probability becomes encapsulated. This sometimes happens even in quite large psoas abscesses.

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[1] Cossy: Bull. Soc. Anat., 1877, 541, and Gamlet: Bull. Soc. Anat., 1878.

When the abscess is evacuated, for example under good treatment, there is as a rule but slight general disturbance, provided it, by operation or rupture, opens or is opened in such a way, as to give complete drainage; if it is evacuated only in part, and if the cavity of the abscess is large, extending upward to the spinal column by means of a long circuitous channel which does not admit of complete drainage, fever, with septic changes, usually follows the evacuation of the abscess, varying in different cases in amount and extent.

Leucocytosis is not, however, always present in such abscesses, nor if it is present is it an indication that pyogenic bacteria are present in the abscess.[1]

As a rule abscesses which burst externally spontaneously are very likely to discharge from pouting sinuses for an indefinite time, often for years. This tendency seems to be diminished by thorough operative treatment of the abscesses, establishing perfect drainage, but even then the seat of disease is often inaccessible and for a long time the abscess cavity may discharge from sinuses.

Diagnosis.

The ordinary clinical history of a case is of little value as an aid in establishing the presence of the disease. It may be significant enough to create a strong suspicion of the existence of vertebral disease,

Fig. 37.—Rigidity of Spine in Pott's Disease. (Children's Hospital Report.)

but without definite physical signs, a diagnosis of Pott's disease cannot be made. Too much importance must not be allowed to the tendency of the parents to attribute the condition to traumatism. It should be men-

[1] P. K. Brown: Occidental Med. Times. 1897, xi.; John Dane: Boston Med. and Surg. Journ., 1895.

tioned that the absence of pain can in no way be assumed to show the absence of Pott's disease.

The diagnosis, then, must be made wholly from the physical examination, and the chief physical signs upon which one must rely can be divided into two classes: (*a*) those occurring from bony destruction; and (*b*) those dependent upon muscular spasm.

(*a*) *Signs due to Bony Destruction.*—Since these are made evident by the presence of angular deformity of the spine, which is the result of bony destruction, they are so conspicuous that they can scarcely be overlooked. And the prominence of one or more of the vertebral bodies, associated with muscular spasm, is a positive sign of the presence of the disease, unless it is the result of a fracture of the spine, or in adults the

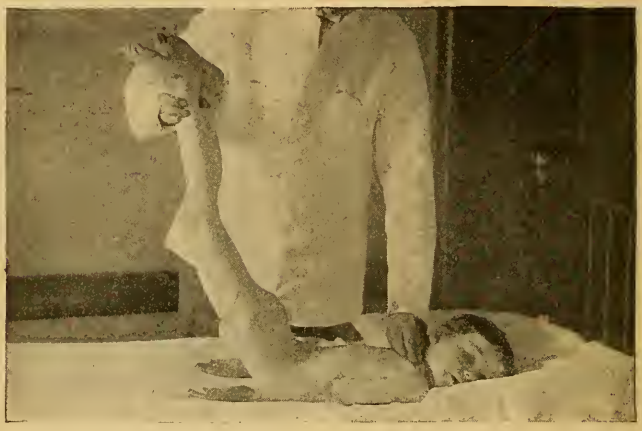

FIG. 38.—Normal Flexibility of Spine. (Children's Hospital Report.)

outcome of malignant disease, aneurism of the aorta, or some similar affection. In the larger number of cases, as they come to the surgeon, this bony deformity has occurred, and the diagnosis can be made at a glance; but the most important class of cases, so far as the diagnosis is concerned, are those in which bony destruction has not yet begun, and in which the need of an early diagnosis is evident, in the hope that it may lead to treatment which may be sufficient to prevent the occurrence of deformity.

(*b*) *Signs Arising from Muscular Spasm.*—These are:

1. Stiffness of the spine in walking and in passive manipulation.

2. Peculiarity of gait and attitudes assumed, according to the location of the disease.

3. Lateral deviation of the spine.[1]

For all examinations children should be stripped.

[1] Boston Med. and Surg. Jour., October 9th, 1890.

1. *Muscular Stiffness.*—On examining for muscular stiffness of the spine, the child is most conveniently laid face downward on a table or bed, and lifted by the feet. In a normal back the lumbar and lower dorsal spine can be markedly bent, and a general mobility of the whole column is seen. In patients in whom Pott's disease is present the region affected is held rigidly by muscular contraction when manipulation is attempted. In certain instances the erector spinæ muscles stand out like cords when the child is lifted, and it is questionable how much importance should be attributed to this sign; it occurs in cases of hip disease, and in certain instances in excitable children in whom no joint disease is present. Lifting the patient by the feet in this way will show the existence of lumbar or lower dorsal rigidity; but it does not detect high

FIG. 39.—Testing for Psoas Contraction. (Children's Hospital Report.)

dorsal Pott's disease. In lumbar Pott's disease lateral mobility of the spine, as well as antero-posterior flexibility, is lost.

2. *Peculiar Gait and Attitudes.*—In considering the gait as a diagnostic symptom of Pott's disease, one must be prepared to find any of the characteristic features absent. In general the walk is careful, steady, and military, and the steps are taken with such care that jars to the spine are avoided; in other instances, however, the child walks with comparative freedom, even when the presence of the disease is manifest, and the well-known test of having the child pick up objects from the floor may fail to detect anything.

Assuming, then, the extreme importance of the early diagnosis of the disease when practicable, it becomes necessary to consider in detail the deviations from the normal signs, according to the region of the spine affected.

Cervical Pott's Disease.—The most common symptom of the disease in this region, due to muscular rigidity, is the occurrence of wry-neck

with stiffness of the muscles of the back and neck. This is often accompanied by distressed breathing at night, and intense occipital neuralgia. The head is held sometimes in a very much distorted position, and the most characteristic attitude is when the chin is supported in the hand; and when the patient turns sideways to look at objects, the whole body is turned. In severe cases one notices flattening of the back of the neck, with sometimes bony deformity. When spinal disease occurs in this region the early symptoms are most often confused with sprains, muscular torticollis, and inflammation of the cervical lymphatic glands.

From sprains the immediate diagnosis is almost impossible. In the early stages of sprains of the neck the head is often held stiffly and to

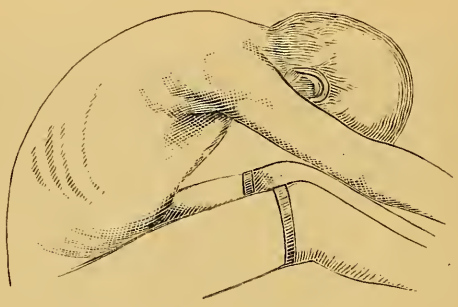

FIG. 40.—Normal Flexion of Spinal Column.

one side; motion is resisted and is painful, muscular spasm is present, and in the case of children of unintelligent parents the history cannot be accepted as valid.

From true muscular wry-neck the diagnosis is often extremely difficult. In congenital torticollis manipulation is generally not painful, and one muscle is firmly contracted while the rest are relaxed. In congenital cases the head and face are distorted, and the eyes often are not upon the same plane. In Pott's disease, on the other hand, the muscular fixation involves all the muscles, and movement in any direction is resisted, and is more apt to be painful. This applies fairly well to cases of anterior wry-neck; but in cases in which the true muscular torticollis is of the posterior variety, and is due to a contraction of the deeper muscles, the diagnosis is much more difficult, for no one muscle is contracted, and movement is limited by a general muscular resistance. The writers have in mind cases in which the diagnosis has been impossible, and some in which an operation of tenotomy has been performed in cases of Pott's disease in which a most careful examination had seemed to establish the diagnosis of true muscular wry-neck.

The differential diagnosis can be most easily made by putting the patient to bed and seeing if the application of extension is sufficient to overcome the distortion, as it will do in the course of a few days if

due to Pott's disease. Rheumatic torticollis simulates cervical Pott's disease so closely that the physical signs are not sufficient at first to differentiate the affections.

Inflammation of the lymphatic glands of the neck may give rise to a position of the head simulating wry-neck, associated with muscular spasm.

Upper Dorsal Pott's Disease.—In this region detection is the most easy because any bony destruction at once results in angular deformity, on account of the posterior curve of the spine in this part, and it is on this deformity that one must depend rather than on symptoms due to muscular stiffness.

The shoulders are, however, held high and squarely, the gait is military and careful, and lateral deviation is almost certainly present. In Pott's disease, paralysis may exceptionally be the first perceptible symptom.

The two affections with which dorsal Pott's disease is most likely to be confused are scoliosis and round shoulders. From rotary lateral curvature with rigidity the distinction may be difficult in cases in which the kyphosis is rounded and involves several vertebræ. The fact that lateral deviation of the spine is so constantly associated with Pott's disease is another factor in making the distinction more difficult.

From round shoulders, Pott's disease is generally to be distinguished by the fact that in the former the spine is flexible and the deformity rounded and not angular. The distinction is generally easily made.

Lumbar Pott's Disease.—Vertebral disease in this region of the spine is difficult of detection on account of the anterior curve of the spine in the lumbar region, so that in any moderate amount of destruction of the lumbar vertebral bodies no posterior angular curvature is developed, and it is only in the later stages of the disease that any angularity becomes prominent. The occurrence of deformity is preceded by a flattening of the lumbar curve. The attitude is that of lordosis, which in some cases becomes very marked; the gait is military and careful, and lateral deviation is generally present, sometimes to a very marked degree. It is in this region of the spine that it is most conspicuous.

In many instances of lumbar Pott's disease the first noticeable symptom is a limp which is due to unilateral psoas contraction, the result perhaps of abscess or perhaps only of psoas irritability. Psoas contraction must be set down as one of the common symptoms of lumbar Pott's disease. If the child is laid on its face and an attempt is made to flex the lumbar spine, it is found to be entirely rigid. Any attempt to hyperextend the leg in this position leads to the detection of the slightest psoas irritability.

Lumbar Pott's disease is most liable to be confused with single or double hip disease, and with rhachitic curvature of the spine.

The differential diagnosis between lumbar Pott's disease and hip disease is one at times difficult, although it is not generally considered so. When the hip symptoms are due to Pott's disease and are caused by psoas irritability, the restriction of motion in the hip is simply in the loss of hyperextension, while abduction and internal rotation are free and not affected. This limitation of motion in only one direction is generally sufficient, in connection with the other symptoms, to establish the presence of Pott's disease. On the other hand, in some cases the limitation of the hip's motion is in all directions, and simulates very closely the limitation of true hip disease.

Another element which leads to the confusion of the two affections is the rigidity of the lumbar spine which often occurs as an accompaniment of acute hip disease. If a child with hip disease is laid upon its face, and an attempt made to flex the lumbar spine by lifting the feet from the table, the irritability of all the muscles is so great that often the lumbar spine will appear to be completely rigid, and only a very careful examination will show that this is secondary to the hip disease.

Rhachitic deformity of the spine is a posterior curvature often so sharp as to be angular. It occurs at the junction of the dorsal and the lumbar regions. This junction is also a frequent site of Pott's disease. Muscular stiffness may not be present.

Rhachitic curvature of the spine is characterized by persistent stiffness in most cases, so that if the child is laid upon its face, and an attempt is made to flex the spine, the curve is not obliterated. The symptoms, therefore, are the same that would be presented by Pott's disease occurring under the same conditions, and much dependence must be placed upon the coexistence of rickets. It is often of use to treat such cases by rest on a frame, and if the curve is rhachitic, mobility will be restored to the back within the course of a few months.

The Diagnosis of Abscess.—The diagnosis of abscess in Pott's disease rarely presents any difficulty, but in certain instances their occurrence is attended with peculiar symptoms which may give rise to some obscurity. In the cervical region the most common seat of abscess formation is in the back wall of the pharynx, where it often persists for some time unrecognized, giving rise to a peculiar series of respiratory symptoms. The pharyngeal wall is pushed forward, and the child breathes at night with a peculiar snoring respiration, which is to a certain extent characteristic. There is some difficulty in swallowing food; the pain is apt to be severe; and occasionally a swelling extends so much to the side as to be noticeable at the side of the neck. The finger introduced into the mouth comes upon a projecting swelling of the back of the pharynx, which is characteristic and not to be mistaken.

In the dorsal and lumbar region the abscesses point for the most part in the loin, or follow down the course of the psoas muscle to appear in

the upper part of the thigh or groin. Appearing in the back the abscess is not likely to be mistaken for anything unless for an abscess of the back muscles or a lipoma.

Appearing in the groin the abscess may be mistaken for hernia which it sometimes resembles rather closely, and gives a certain obscure impulse on coughing; but it is irreducible and the part of the psoas muscle within the abdomen can be felt to be enlarged and resistant. Psoas contraction is present, which causes flexion of the leg.

The Diagnosis of Paralysis.—Paralysis in Pott's disease, although ordinarily one of the later symptoms, may occasionally precede the deformity, and be the first sign of the presence of vertebral disease. Such cases are not so rare that they should be overlooked. The occurrence of myelitis in a young child should be considered as extremely suspicious, and as being more likely to be due to Pott's disease than to any other cause, even if the signs of vertebral disease are obscure or apparently absent. In general the paralysis is preceded by a stage of the disease in which pain is much increased. Ordinarily one of the first demonstrable signs is an increase of the patella reflexes, with perhaps ankle clonus.

Sprain.—It is difficult at times to differentiate *a sprain of the vertebral column* from Pott's disease. After a fall in which the back has been wrenched, a child begins to walk stiffly and to complain of pain in the back and perhaps in the legs. Attitudes characteristic of Pott's disease are assumed, the trunk is supported with the hands upon the thighs, the back is kept stiff in stooping, and passive manipulation shows that muscular rigidity is present. At an early stage a diagnosis is sometimes clearly impossible. But in sprains of the back the tendency is to a rapid recovery under proper conditions, and the result establishes the diagnosis. Severe sprains of the back are comparatively rare in childhood, but in adult males engaged in laborious occupation cases of strain are more common than cases of Pott's disease. The diagnosis is one which should be made in childhood with very great reserve.

Rotary lateral curvature of the spine is an entirely different affection from Pott's disease. It is not the result of a tuberculous destruction of bone, but is the result of a distorted and abnormal process of growth. It is characterized not by an angular projection of the spine backward, but by a gradual curve of the spine laterally with a rotation of the vertebral column on its long axis. Pain is not present, and the recognition of the affection is generally due to an alteration in the outlines of the trunk, and a prominence of the shoulder or hip.

In most cases the diagnosis is not at all obscure. But in the course of Pott's disease at an early stage a lateral deviation may be present, which may be mistaken for lateral curvature. On a careful examination it will, however, be found that a stiffness of the back is present which

is never to be seen at an early stage of lateral curvature. In some instances careful and repeated examinations are needed to establish a positive opinion.

A lateral deviation takes place also sometimes in old cases of caries of the spine in connection with an old kyphotic curve.

Hyperæsthetic spine, also termed the hysterical spine, and the neuromimetic spine, is characterized by tenderness in certain portions of the back, sometimes accompanied by pain or ache. This condition is more common in neurotic persons, but may be seen in others who have been suffering from nervous exhaustion from any cause. It generally follows some slight or severe accident and generally occurs in persons with weak back muscles. The tenderness may be intense and manifestly exaggerated, or it may be only slight, and confined to small spots in the lower cervical and upper dorsal or in the upper lumbar region. As a rule, no real stiffness in the back is present, but in severe cases, or in cases which have remained in bed for some time, muscular stiffness may be present. This condition is sometimes seen after railway accidents. In the cases that are termed "railway spine," abnormal projection or deformity in the spine does not exist, although lax ligaments and weak muscles permit a flexed condition of the spinal column in standing, which may make one or two vertebræ unduly prominent as the patient stands erect, but this prominence disappears in recumbency. Referred pains, or the attitude and gait characteristic of Pott's disease, are absent. A hyperæsthetic spine occurs in adults, and especially in growing young girls; it may exceptionally be seen in children.

Malignant disease of the spine presents, when a projection is found, a more rounded and less sharp projection than is seen in the beginning of caries. Carcinoma of the spine is usually secondary. The symptoms, however—pseudo-neuralgias, paresis and paralysis, muscular stiffness—are the same in both, and sometimes only a conjectural diagnosis can be made. Sarcoma of the spine is very rare in childhood.

Much the same may be said of the curvatures of the spine caused by aneurism, except that the diagnosis is usually made by auscultation or by the rational symptoms before the spine is noticeably affected.

Tumors pressing on the spinal cord may cause stiffness of the back and pain referred to the peripheral ends of the nerves. Angular deformity, however, is absent, and the symptoms of nervous disturbance predominate over the ordinary ones of Pott's disease.

Traumatic Spondylitis.—A condition in the spine is said to exist, after severe traumatism, which simulates Pott's disease. The distinction between a non-infectious destructive inflammation of the vertebræ and a tuberculous inflammation cannot be made ante mortem in most cases, except possibly by the injection of tuberculin. The same may be said of *actinomycosis* of the spine.

Syphilis of the spine must be diagnosticated by general symptoms rather than by any well-known characteristics that it possesses.

Osteomyelitis of the spine affects most often children; it may be secondary or primary. The back part of the vertebral column is often affected, and tenderness is present at the seat of disease. Suppuration elsewhere occurs in sixty per cent of all cases. There is much constitutional disturbance, fever is high, and the course rapid. Œdema of the affected parts appears early; abscesses of a very acute and extensive character as well as paralysis are other early features. The formation of a kyphus of any extent is unusual.[1]

Acute abdominal affections may simulate severe Pott's disease. In a case seen by the writers fixation of the spine was a most evident feature.

Spondylolisthesis may resemble Pott's disease. The same may be said of typhoid spine. These will be described later.

Rheumatoid arthritis (spondylitis deformans of the spine) is an affection most frequent in adult life, characterized by stiffness and some arching of the spine; there is usually little muscular spasm and no unusual projection of the spinous processes; in some instances the ribs are ankylosed to the spine, so that no expansion of the chest is possible. Stiffness of the back is present, but the whole spine is rigid and other joints are involved. Many of these cases occur in connection with gonorrhœa. Patients suffering from this affection may have neuralgic or pseudo-neuralgic pains of the nerves issuing from the spine at the affected part.

With regard to the symptoms of sacro-iliac disease, perinephritis, and appendicitis, it may be said that a mistake in diagnosis may happen, but that ordinarily there is no obscurity. It should, however, be borne in mind that in appendicitis and in perinephritis, when an abscess is present, a contraction of the thigh may occur, resembling that seen in psoas abscess. The absence of a projection or irregularity of the back, and the power of muscular movement of the back in these cases, will help to establish the fact that they are not due to disease of the spine.

Prognosis.

Pott's disease will always be regarded as one of the most formidable of diseases; its long course, the deformity entailed, the severity of the complications, and the occasional termination in death give both to the surgeon and to the non-professional public a natural dread of the affection. These inferences are, however, drawn from the severer cases, and facts show that the disease has a tendency to spontaneous recovery, that in certain parts of the spine deformity can be prevented, and that in few

[1] Ann. of Surg., 1896, xxiii., 510; Hahn: Beitr. f. klin. Chir., xiv., Hft. 1; Müller: Deutsch. Zeit. f. Chir., xli.

affections does the work of the surgeon give greater relief than in Pott's disease.

Mortality.—No statistics of value exist as to the percentage of mortality and recovery. Billroth and Menzel report 23 deaths in 61 cases; Jaffé 22 deaths in 82 cases, and Mohr 7 deaths in 72 cases. In a disease having so long a course, a number of patients should be watched for a long number of years in order to obtain statistics of value. The percentage of mortality would be greater in adults than in children. In a certain number of cases spontaneous recovery has taken place in early childhood. Many specimens in museums also exist, which show bony union with entire cessation of the pathological process.

Billroth and Menzel found, in autopsies of 702 cases, tuberculosis of other parts of the body in more than one-half (56 per cent). Amyloid

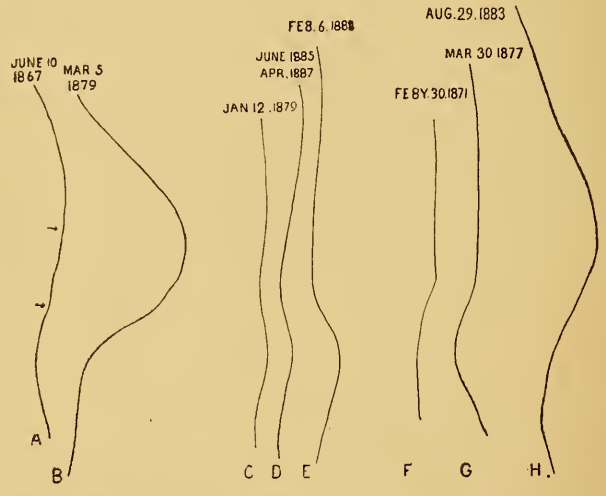

FIG. 41.—Tracings of the Deformity in Pott's Disease. *A B*, not treated; *C D E*, patient did not continue treatment; *F G H*, patient discontinued treatment. (H. L. Taylor.)

degeneration was found in 15 per cent of the cases, and fatty degeneration of the kidney in 22 per cent. Mohr, however, found the latter in only 6 per cent of the cases collected by him. Mohr found tuberculosis of the lungs in only 8 out of 61 autopsies.

Michel gives as causes of death in 44 cases of spinal abscess: in 14, tuberculosis of lungs; in 16, marasmus; in 5, sloughing of limbs from œdema; in 4, pyæmia; in 2, arachnitis; in 2, pus in the medullary canal; and in 1, pneumonia.

Neidert investigated the cause of death in patients with angular deformities of the spine, the result of Pott's disease, which had been cured. Patients with severe deformities ordinarily die of heart fatigue, patients with medium-sized curvatures die oftenest of phthisis and die young,

while those with small deformities have nearly as good a prospect of long life as men with normal spines. These results were obtained from the investigation of 31 specimens in the Munich Pathological Institute. Twenty-four had hypertrophy, with or without dilatation of the right side of the heart, 4 had muscular degeneration of the heart walls, and 2 had stenosis of the mitral valve, 1 showed acute miliary tuberculosis, 8 died of phthisis, 4 of pneumonia, and 1 of carbuncle.[1]

FIG. 42.—Result in a Severe Case of Dorsal Pott's Disease.

Mohr, in 9 cases of fatal abscess, found perforation into the œsophagus in 2; pleura and lungs in 2; pleura alone in 1; peritoneum in 1; spinal canal in 2. Death has occurred from the rupture of a spinal abscess, which has discharged into the bronchi.

Abscesses in adults must be looked upon as much more unfavorable as to prognosis than in children. The prognosis will depend largely upon the situation of the abscess, the completeness of evacuation, and the amount of drainage possible.

The occurrence of psoas abscess and contraction of the thighs will add much to the difficulty and the length of treatment. Abscess in itself does not make the prognosis much more grave, although, as a rule, abscesses characterize severer grades of cases. The discharge is likely to be prolonged and exhausting, and the sinuses are likely to continue open for a long time, perhaps for months and years.

Age.—The prognosis in the case of adults is not nearly so favorable

FIG. 43.—Case of Neglected Pott's Disease with Psoas Contraction and Severe Deformity.

as in the case of children, and it should be very guarded both as to ultimate recovery and the permanent benefit to be derived from treatment.

[1] "Causes of Death in Deformities of Vertebral Column," Inaug. Diss., Munich, 1886.

Phthisis is more likely to develop than in children, and the local process seems to possess an activity greater than in young children.

Deformity.—The tendency of the deformity is to increase, and this is specially marked in the upper dorsal region. Instances of arrest without marked deformity are not so very rare in upper cervical disease and in lumbar disease, but in the upper and middle dorsal regions the tendency is for an increase of the deformity proportionate to the extent of the

FIG. 44.—Child with Pott's Disease Picking up Object from Floor.

Fig. 45.—Normal Child Picking up Object from Floor.

disease. In most cases, some arrest of the growth of the whole child takes place apart from the loss of vertebral substance. The cure from Pott's disease may be so complete as to permit normal labor, provided no distortion of the pelvis has taken place.[1]

TREATMENT.

This varies according to the stage and condition of the pathological process.

When the destructive ostitis is acute and extensive the affected bone should be protected from all jar and pressure, both that due to superimposed weight and attitude. When cicatrization has begun the spine should be protected so that activity necessary for health may not cause injury in the imperfectly healed bone structure.

[1] Trans. Amer. Orth. Assn., vol. iv.

Protection is necessary until the previously inflamed bone has become cicatrized so thoroughly as to withstand without injury jar and superimposed pressure.

A growing spinal column, even if the vertebræ have recovered from caries, may need support to prevent an increase of curvature by abnormal growth.

Treatment therefore is different in the acute, the subacute, and the convalescent stages. In the acute stage recumbency is the most efficient

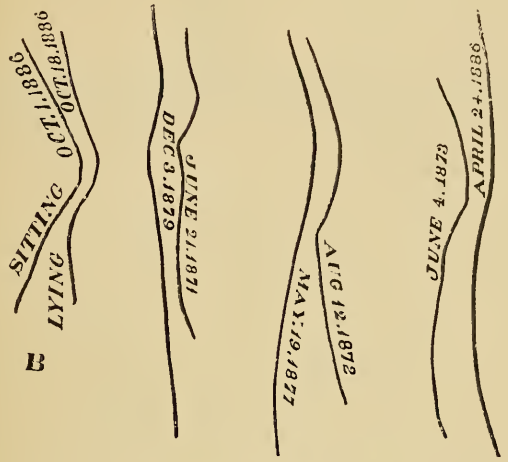

FIG. 46.—Tracings from Cases of Pott's Disease Showing the Recession of the Deformity under Mechanical Treatment.

method. In the subacute and convalescent stage ambulatory treatment with more or less efficient spinal protection is advisable.

TREATMENT BY RECUMBENCY.

If the patient lies upon his back, or upon his face, on a hard surface, there is no superincumbent weight pressing upon any portion of the spine. If the patient lies upon his back upon a spring-bed, and the bed sags, the spine is of course bent, and pressure upon the vertebræ, proportional in amount to the extent of the curve, results.

If treatment by recumbency is to be adopted, it is not sufficient simply to place the child in bed. Sagging of the mattress, moving of the patient from side to side, twisting and turning are all injurious, in that they cause motion between the vertebræ and change interarticular pressure, both of which are undesirable.

It is necessary that the child should be fixed in a suitable position in bed. This can be done by securing the child in such a manner that the vertebral column at the seat of disease is arched forward, diminishing the

interarticular pressure. The simplest way of doing this is by means of a frame.

The rectangular bed frame consists of a stretcher of heavy cloth attached to a rectangular gas-pipe frame. This frame is made of straight pieces of galvanized iron gas-pipe (one-half to one inch in diameter)

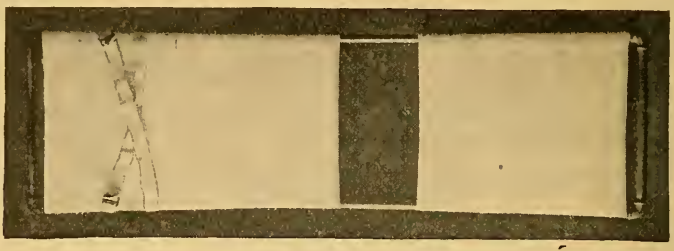

FIG. 47.—Gas-Pipe Frame. (Children's Hospital Report.)

screwed into gasfitter's joints at the four corners. This frame should be four or five inches longer than the patient, and its width should be a little less than the extreme width of the shoulders.

The covering cloth is best made of heavy unbleached cotton sheeting, stretched firmly over the stretcher. The covering should consist of two pieces of such length that the entire space is covered by cloth, except for a space of six inches or less between the two sections at a point corresponding to the buttocks. The cloth covering can be stretched tightly, and this may be done in one of several ways. The most convenient way

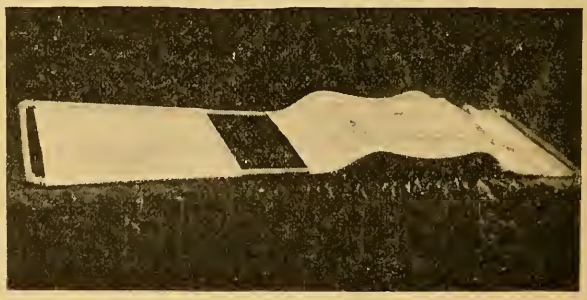

FIG. 48.—Gas-Pipe Selva Frame Covered. (Children's Hospital Report.)

is by lacing each section at the back of the frame. Hemmed lacing holes are made in the doubled edge of the cloth, about an inch apart, and a stout lacing is passed from one to the other. Buckles and webbing straps may be used in place of the lacing, but the buckles are likely to press upon the patient's back, and the lacing is preferable.

The child lying upon this frame can be secured by means of straps across the shoulders and pelvis and knees, and can be carried about with-

out jar. When the frame is placed upon the bed, the cloth covering is no more uncomfortable than the surface of the bed.

But simple recumbency is not sufficient to favor cicatricial ostitis. The removal of intervertebral pressure is desired. This is to be accomplished by arching the spinal column forward at the point of the kyphotic curve. When the cicatrization has not progressed so far as to produce ankylosis, correction (partial or complete) of the curve can be effected by placing under the curve of the child lying upon the back a firm pad, pressing upon each side of the spinous process, and sufficiently high to press this part upward while the rest of the spinal column drops back by

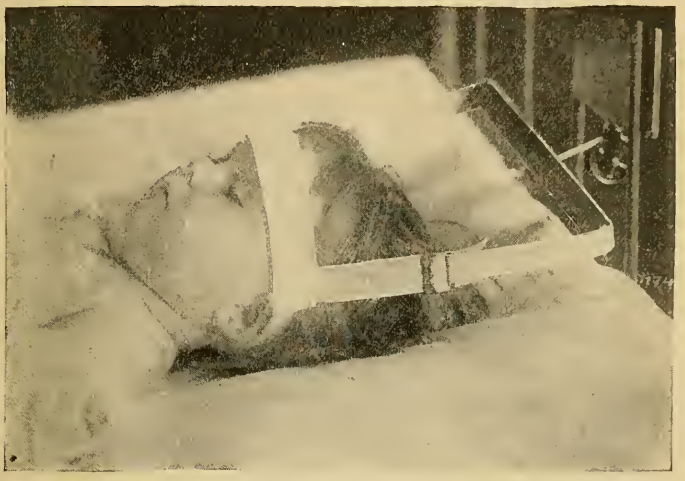

FIG. 49.—Traction in Cervical Caries. (Children's Hospital Report.)

its own weight. The pads can be furnished by properly folded sheets or towels, by felt padding, or by a plaster-of-Paris back moulded to a corrected position of the spine.[1]

A child undergoing treatment on the frame should be turned once a day to have the back washed, rubbed with alcohol, and powdered. It is important that there should be no pads in the median line immediately above or below the deformity, but that the pads should lie entirely outside of the line of the spinous processes. To secure better fixation it may at times be necessary to place pads under the lumbar region.

In cervical caries head traction in a recumbent position will be found of use in cases of torticollis; and in severe neuralgia from cervical caries

[1] The need of support under the recumbent spinal column is made clear by some interesting observations made by Dr. H. J. Hall, of Marblehead, on the spinal column with the patient lying upon a transparent glass plate. This showed conclusively that even on a firm surface support is needed under a portion of the spine (*vide* Trans. Am. Orthopedic Association, vol. ix.).

the relief afforded is often very marked. Traction can be furnished by means of a head sling passing over the forehead and occiput, which is attached to a weight and pulley running over the head of the bed or to the head of the frame. The counter pull may be furnished by the weight of the body in case the head of the bed is raised, by a downward pull upon the trunk through a waist band, or by means of traction applied to the limbs.

Treatment by recumbency will be found of service, either alone or in conjunction with other methods, in cases with acute symptoms, in cases of severe cervical caries, in cases with marked lateral deviation of the spine, in paralysis, in cases of psoas contraction and abscess, in cases which do not progress well under ambulatory treatment, and which lose flesh and strength, and in very small children in whom the difficulty of fixing the spine by apparatus is great.

Patients who have been suffering will often be found to gain flesh after the relief afforded by recumbency, though the muscles in the limbs diminish in size.

Treatment by recumbency, if used, should be thorough. Half measures have the evils of the imprisonment without the benefit of fixation. The limit of its usefulness is usually marked by the restlessness of the patient. In children the irksomeness of the confinement is borne readily; but in adults the imprisonment constitutes a serious obstacle to the employment of the method.

The objections to treatment by recumbency are evident. Pott's disease is a tuberculous affection and close confinement is injurious to patients with a tuberculous taint. Patients of this sort need all possible help from fresh air and exercise, and the method of treatment by recumbency for years, formerly the only thorough method possible, is not now regarded as necessary in all cases.[1]

In cases causing much anxiety, recumbency should for a while form an essential part of the treatment. If recumbency is continued for too long a period, the patient's condition ceases to improve and the tonic of improved circulation and activity is required. After some experience a surgeon will learn to estimate for what cases recumbency is most advisable. It may be stated that such patients as become easily tired when on their feet and those who, though well supported mechanically, frequently desire to lie down, will improve if all weight can be taken from the spinal column.

When the time for recumbency is judged to be ended it should not be

[1] It must be remembered that all apparatus is necessarily imperfect from a mechanical point of view and must fail in wholly relieving the diseased vertebræ of their weight-bearing function, so that within its limitations recumbency is to be recognized as mechanically the most efficient mode of treatment and the least likely to encourage deformity.

discontinued suddenly, but the patient should be gradually allowed to sit up and walk with proper mechanical support. In cases convalescent from paralysis and in cases in which the general prostration is extreme, exercise may be obtained by the use of one of the wheel crutches, such as Darrach's. In convalescent cases ambulatory treatment with hours of rest in the recumbent position each day should constitute the treatment.

Rectification of the Deformity (Forcible Correction).—The treatment of Pott's disease by forcible correction may be considered as an adjunct to the methods of treatment mentioned. Forcible correction of the deformity, with or without anæsthesia, is a method revived in recent times by Chipault of Paris, although ordinarily identified with the name of Calot of Berck-sur-Mer. Chipault operated first in Sep-

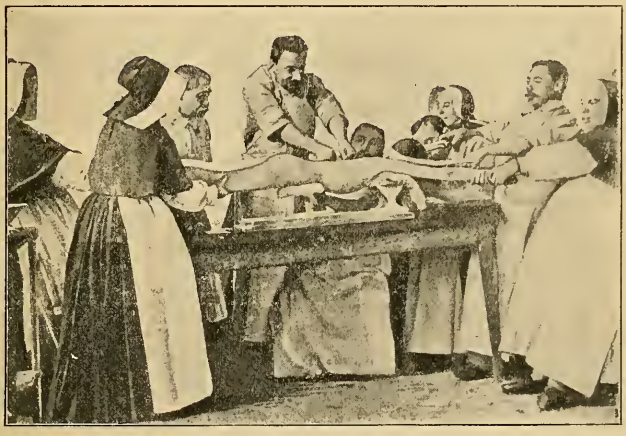

FIG. 50.—Reduction by the Method of Calot. (Redard.)

tember, 1893, reducing the deformity, wiring together the spinous processes of the affected vertebræ. He published an account of this method on March 9th, 1895.[1] Calot published a paper on the method on December 22d, 1896, in which he said that his first operations "dated back only a little over a year." The priority of forcible reduction belongs clearly to Chipault. Wiring of the spinous processes of the vertebræ was, however, first advocated by an American, B. E. Hadra, in a paper read and discussed before the American Orthopedic Association at Washington, September 24th, 1891. The method has been largely advocated and finds a place in modern orthopedic treatment.[2] It has been demonstrated that under ether a recent deformity, even of large size, may be partially or wholly corrected. Also that much temporary

[1] Médecine Moderne, No. 20, sixième année.

[2] Monod: Gaz. des Hôp., 1897, 70, 656; Menard: Gaz. Méd. de Paris, 1897, 10, S. i., 231.

improvement in the deformity may be effected by exerting traction or moderate pressure on the deformity without the use of an anæsthetic. It has been shown that this is not a proceeding attended with as great risk to life,[1] either near or remote, as would have been supposed. Many casualties, however, of various sorts have been reported.[2] It has been shown that paralysis is often improved or cured by this manipulation, although cases of paralysis occurring after it have been reported.[3]

Hemorrhage, rupture of the pleura,[4] rupture of abscesses,[5] and fracture of the spine[6] are among the results reported, following injudicious application of the method.

In 610 cases[7] recorded by twenty-nine various operators, the results reported have been as follows:

Length of time elapsed:
- Varies from 2 days to 2½ years.
- In separately detailed cases:
  - 7 were more than 1 year after correction.
  - 85 " " " 6 months " "
  - 25 " " " 3 " " "
  - 20 " less " 3 " " "

Deaths reported:
- From all causes..... 21
  - Meningitis..... 5
  - General tuberculosis..... 4
  - Trauma of the operation..... 4
  - Intercurrent disease..... 3
  - Unstated..... 5
- Autopsies:
  - All showed a considerable local trauma. No case showed effectual effort at repair. (One being two and one-half years subsequent to correction.)

Immediate dangers:
- Respiratory embarrassment..... 7 cases.
- Pain..... 6 "
- Shock (severe)..... 2 "

Indirect effect:
- Abscess.
  - Reported present before the operation..... 18 cases.
  - Ruptured..... 4 cases.
  - Benefited or absorbed..... 5 "
  - Appeared subsequently..... 2 "

---

[1] Calot, *e.g.*, 204 cases, 2 deaths inside of eight months.

[2] Jonnesco: Communication to Twelfth International Congress of Medicine.

[3] Lorenz: Deutsch. med. Wochen., 1897, 556.

[4] Wullstein: Arch. f. klin. Chir., lvii. 485.

[5] Menard: Gaz. Méd. de Paris, 1897, S. i., 231.

[6] Matherlie: Ann. de Chir. et d'Orth., July, 1897, 218.

[7] E. H. Bradford and Vose, giving bibliography, Trans. Am. Surgical Ass'n, 1899.

Paralysis.	
Present before the operation	31 cases.
Relieved (complete or partial)	17 cases.
Not relieved	2 "
Not stated	8 "
Appeared (partial only)	4 cases.
General condition.	
Reported distinctly improved	7 cases.
Direct effect on deformity:	
At the time of operation, stated in	229 cases.
Complete correction	119 cases
Incomplete correction	94 "
No gain	16 "
Result three months later (cases with some gain)	66 cases.
No relapse	17 cases.
Some relapse	44 "
Total relapse	5 "

It is obvious from the inspection of any series of pathological specimens of cured cases of Pott's disease that the diseased tissue is replaced by sound bony tissue to hold the disabled column, if time enough is given and if the process of repair has not been overwhelmed by the process of destruction. It is asserted that the gap between the bodies of the vertebræ, which is caused by their forcible separation, is filled in very rapidly with new bone. This gap may be from two to three inches. This assertion, however, is not supported by accurate evidence, nor is it in accordance with pathological facts.

Sherman (*l. c.*) reports a case of great interest. A very severe deformity in a boy, eight years old, in the dorsal region was corrected by routine methods. The patient died three months after operation, and an autopsy showed marked separation of the vertebral bodies but no attempt at bony repair. Murray quoted two autopsies done two and three months after forcible correction, in neither of which was there any attempt at bony repair.[1] Noble Smith reported a case in which, two and one-half years after the correction of a deformity in Pott's disease by the prone position, a soft bony growth filled in the gap between the vertebræ, but it was so delicate that it was washed away during maceration.[2]

Two questions suggest themselves: the first, how much force is needed in this procedure; the second, the best means of applying the force. The amount of force required depends upon what is attempted. If it is desired to break up any ossification, a great deal of force would be necessary; when the amount of cicatrizing ostitis is slight, slight force is required. When the power is used to a mechanical advantage, less will be needed for the required correction. It is for this reason that the plan which has been in use at the Boston Children's Hospital for the

[1] Amer. Jour. Med. Sciences, May, 1898.
[2] Brit. Med. Jour., February 19th, 1898.

past two years will be found to have certain advantages. In this but little force is employed, and that well under control, the diseased projection being used as the central resistant point; and the weight of the trunk

FIG. 51.—Vertebral Column after Forcible Reduction. (Sherman.)

on each side of this point acts as a straightening force. The appliance by which this correction can be done is as follows: An upright which can be raised or lowered by an adjustable screw is furnished with a steel

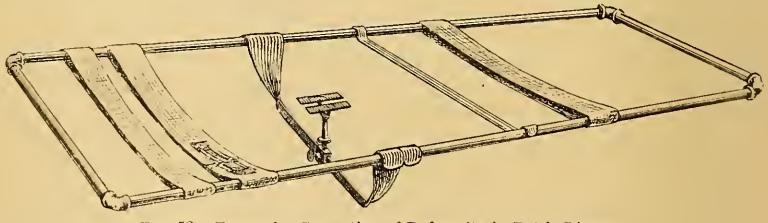

FIG. 52.—Frame for Correction of Deformity in Pott's Disease.

top, having tips so arranged as to steady a zinc plate equipped with holes, placed so as to press at each side of the vertebral spines. If these plates are padded and placed beneath the patient in such a way that they will lie on each side of the spines at the point of projection, an upward pressure can be exerted by raising the upright by means of the screw attachment. If this is raised to such a height that the head and pelvis hang from a suspended trunk, it is manifest that a strong force is exerted

to straighten the spine and correct the curve. This can be increased if necessary by a traction or pressure force upon the limbs or upon the head and shoulders.

Goldthwait, who employed the method, placed steel bars to lie close to the spine as a means of correcting lordosis, and attached the uprights to an oblong frame, using cross bars and straps as a support for the trunk. The unusually successful cases reported by him before the American Orthopedic Association warrant the assertion that the method is equally successful with that requiring the employment of great force. It will be found that the patient suffers but little discomfort, that the jacket can be applied readily, and in practice no anæsthetic is used, as it has been found that sufficient force can be applied without discomfort, and it is believed that force greater than this would be dangerous. When the disease is seated in the upper dorsal region, it is manifest that some head support is required, and this can be furnished by placing felt padding about the neck, and including this in the plaster jacket which passes above the shoulders and includes the head. Instead of this the various forms of head support can be applied to the jacket, or repeated jackets should be applied and a gradual correction obtained in preference to the employment of a great deal of force at one sitting. The amount of correction obtained at each sitting, or after a number of sittings, will depend necessarily upon the pathological conditions, the complete straightening being possible but not practicable in all recent cases.

A simpler and no less efficient way of straightening a curved spine, when the method is applicable, may be described as follows: The patient is placed on the back on any table. A sling made of sufficiently firm cloth and a few inches in width is passed under the child at the greatest prominence of the projection. Between this and the skin a thick layer of saddler's felt is placed. (A hole can be cut out in the felt or later in the jacket to protect the spinous processes.) This sling should pass upward on both sides of the patient, reaching to a cross bar, similar to that used in the ordinary Sayre suspension, and sufficiently wide to keep the ends of the sling from crowding the patient's ribs. The cross bar can be attached to a pulley above the patient; and by raising the cross bar the patient is raised to the point at which it is desirable that the projection should be corrected. The patient can be raised so that the weight of the whole trunk acts as a correcting force; and, if necessary, downward pressure or a downward pull can be exerted upon the pelvis and upon the shoulders, or downward traction can be used upon the arms, head, and shoulders, and in this way all requisite force may be used. If the patient is raised partially from the table, and a pillow or sand bag placed under the head, the trunk will be found sufficiently raised to enable the surgeon to apply plaster rollers in the ordi-

nary way. The plaster bandages can be applied around the sling, and the sling cut off at the place of emergence of the bandages, leaving but a slight opening. This can be covered by an extra layer of bandage, making the jacket perfectly secure.

The advantages of this method are chiefly in its simplicity and its ready use without any complicated apparatus. In fact, a broomstick or bar resting on two high pieces of furniture, and strong bandages or cloth

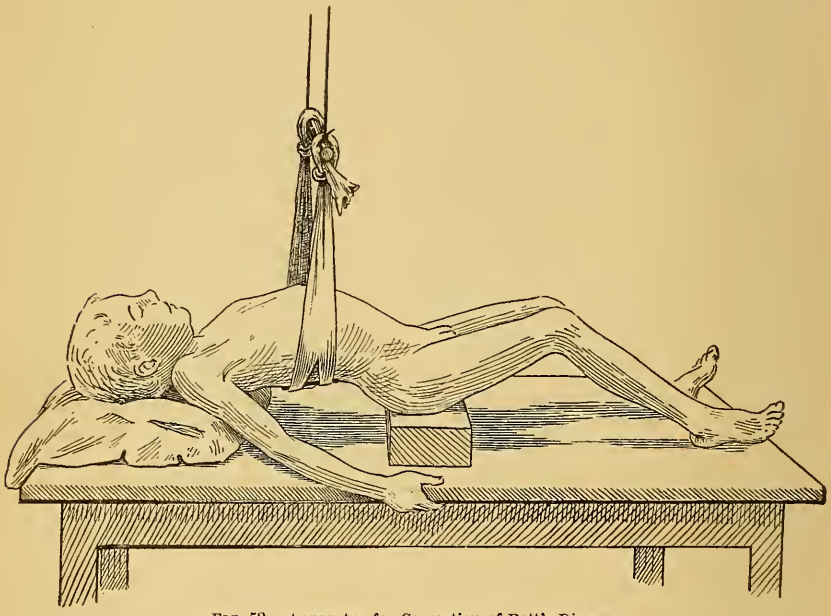

FIG. 53.—Apparatus for Correction of Pott's Disease.

as a sling and a piece of felt would be all that would be necessary in the application of a correcting plaster jacket by any surgeon of skill and experience.[1]

It is evident that no less importance is to be placed upon the retention of a spine in the corrected position than upon the correction itself, for when a cure depends upon a cicatricial ostitis solidifying the weakened and inflamed tissues which have replaced the normal bone, the tendency to a contraction of cicatrizing tissues before ossification has taken place will tend to reproduce the curve, even if thoroughly corrected. As the process of ossification of cicatrizing ostitis is not a rapid one, it is manifest that protection and retention will be required for some time, and the problem of the proper appliance is not a simple one, as the apparatus must be worn

[1] R. T. Taylor, of Baltimore, has recommended an excellent method of the application of correction of the spinal curves and the application of plaster jackets in a sitting position (*vide* Trans. Amer. Orthoped. Association, vol. xii.).

for months and even years. It will therefore appear that the use of forcible correction in Pott's disease is somewhat more limited than was at first supposed; first, by the judicious selection of cases, and second, by the number of cases in which the after-treatment can be properly carried out, for it is manifestly absurd to straighten a spinal column, exposing

FIG. 54.—Pott's Disease before Correction. (Goldthwait.)

FIG. 55.—Same Case Twelve Weeks after Correction. (Goldthwait.)

the patient to a certain amount of risk, and later to allow the patient to relapse into a condition as bad as before the operation.

It is believed that no anæsthetic is necessary if cases in which the procedure is likely to be beneficial are the ones subjected to the treatment. The after-treatment requires attention for years.

Paralysis is often helped by forcible correction, even when of long standing, and a mild pressure may be exerted in most cases without apparent harm, with a view to diminishing deformity. The applicability of the operation in individual cases must be decided on the grounds already given. It is obvious that in no event is the method suitable to cases in which complete bony ankylosis has taken place, as recommended by Calot. In the opinion of the writers no anæsthetic is necessary, as no degree of force requiring anæsthesia should be used.

It is a question of judgment in each case, dependent upon the situation and extent of curve, whether simple recumbency with pad pressure or corrective measures are needed.

Treatment by Appliances

(braces, jackets, and corsets) aims at relieving the diseased vertebræ of at least part of the body weight while the patient goes about with as complete fixation as possible.

Treatment by Plaster Jackets.—Suspending a healthy person by the head diminishes the physiological curves (cervical and lumbar lordosis, dorsal kyphosis), and the spine becomes straight so far as its formation

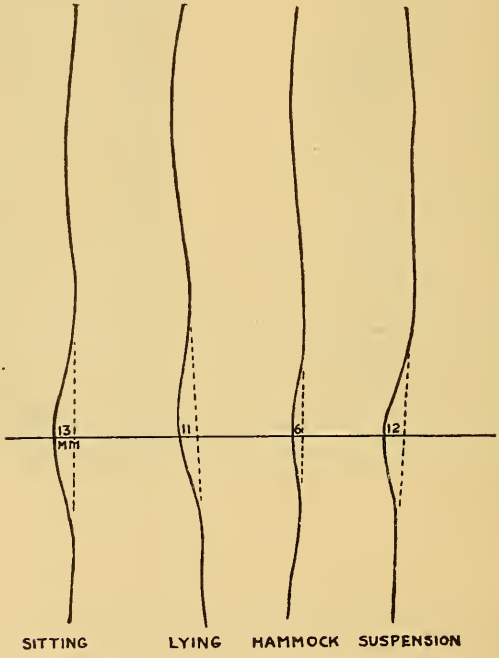

Fig. 56.—Variation in Curves in a Case of Pott's Disease in Different Positions. (Brackett.)

will allow. The spine of a new-born child becomes straight by suspension, but in an adult the shape of the bones, the strength of the ligaments, and the tension of the muscles prevent the spinal column from becoming perfectly straight. In suspension by the axillæ or arms the strain comes upon the latissimus dorsi muscles, and though the weight which would fall upon the lower part of the spinal column is removed, yet the curvatures in the upper part of the spine are not made straight.

In suspension, in old Pott's disease, it is only the physiological curves which are obliterated;[1] the sharp kyphosis is held too firmly by adhesions to permit correction. In earlier cases the intervertebral press-

[1] Anders: Archiv f. klinische Chirurgie, 1889, iii., p. 558.

ure must be, in a measure, diminished at the point of disease by suspension; but suspension does not cause a disappearance of the sharp angular projections at the point of disease, although the kyphus is diminished as shown by Brackett.

The undoubted beneficial effect of plaster jackets is due, not to the separation of the affected vertebræ, but as a fixation support in an improved position.

It was originally supposed that a jacket could be applied so as to serve as a means for holding the diseased vertebræ apart, *i.e.*, as a means of distraction. Suspension having pulled the vertebræ apart, a jacket

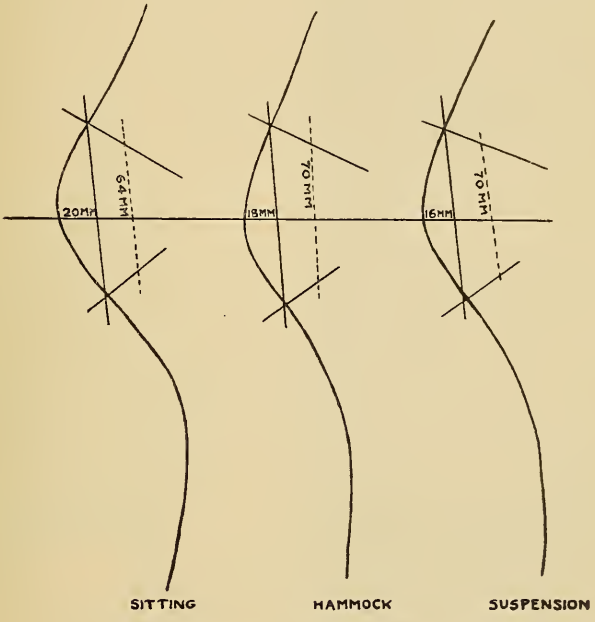

FIG. 57.—Variation in Tracings of Pott's Disease. (Brackett.)

which takes its base-bearing on the pelvis and a purchase on the thorax, would keep these portions from coming together by a vertical support. These ideas are erroneous. Suspension straightens the spinal column somewhat and diminishes antero-posterior curves, and the application of a plaster jacket prevents the column from bending forward. Plaster jackets are efficient not as a means of fixation alone, or of distraction, but as a means of securing comparative fixation in an improved position. The treatment by plaster jackets requires care, for a poor jacket does harm rather than good by deceiving the physician and the patient. For the proper applying of plaster jackets, moreover, a careful attention to detail is necessary.

Bandages are prepared by rolling loose-meshed cloth in dry plaster-of-Paris. The cloth to be chosen is that capable of carrying the most plaster-of-Paris, and presenting as little cloth fibre as possible. "Crinoline[1] lining," which has been washed, will be found to answer this purpose.

Application during Suspension.—The plaster is to be rubbed into the cloth smoothly and to be freed from lumps or unevenness. The patient's clothes are removed and a thin, tightly fitting-undershirt is applied, put on so as to present no wrinkles. The patient is then suspended; the head is secured in a sling, which is attached to a strong cord playing in a pulley, or

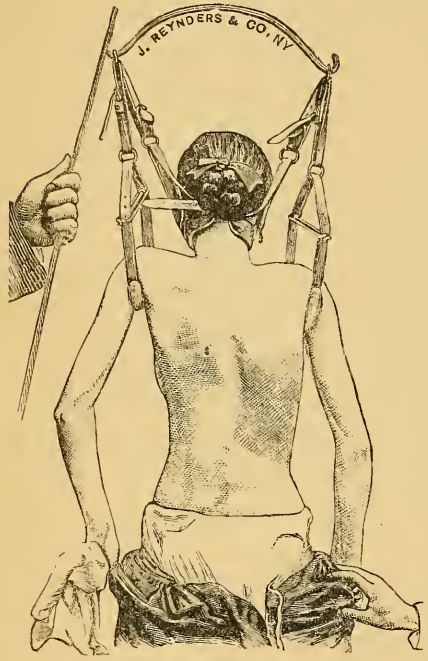

FIG. 58.—Sayre Head-piece for Suspension in Pott's Disease.

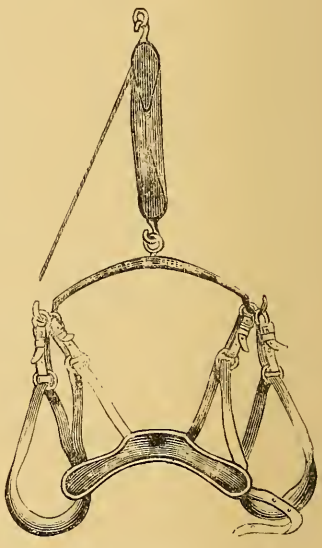

FIG. 59.—Appliance for Suspension.

series of pulleys, fastened to a point above the patient's head. An assistant pulling on the cord raises the patient so that the heels, and if necessary the toes, are free from the floor. It is desirable to diminish the strain upon the neck, and padded loops connected with the bar, which is raised by the cord and pulley, can be passed under each axilla, or handles may be held in each hand, connected with cords which play over pulleys. A pull on the cords raises the patient. Pads

[1] Various forms of gauze have been used for plaster bandages; the gauze should be entirely free from glue sizing, and if stiffened should be stiffened with starch. If glue sizing is present, the gauze needs to be washed, otherwise the quick setting of the bandage will be interfered with. The cloth should be free from oil and absorb water quickly.

are placed over the crests of the ilium, and a large, soft pad over the abdomen. This latter is to be pulled out when the jacket has become hard, and prevents too great a pressure on the abdomen.

The bandages are placed singly on end in water and kept immersed until they are thoroughly wet (*i.e.*, until air bubbles no longer rise in the water from the immersed bandage) and are then wound smoothly around the patient.

If the plaster is fresh and of the best quality, it should harden in five minutes. The hardening can be hastened by putting salt or alum in the water, but this makes the plaster somewhat more brittle. After the plaster is hard or nearly hard, the patient is to be placed on a soft flat surface, care being taken not to crack the plaster in so doing.

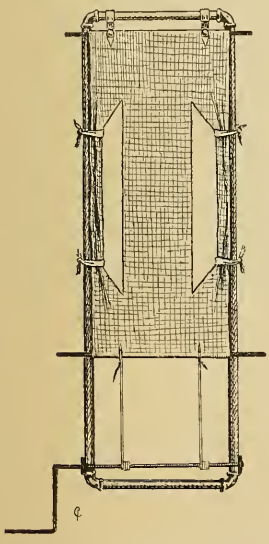

FIG. 60.—Frame for Application of Jackets during Recumbency, Ready for Use.

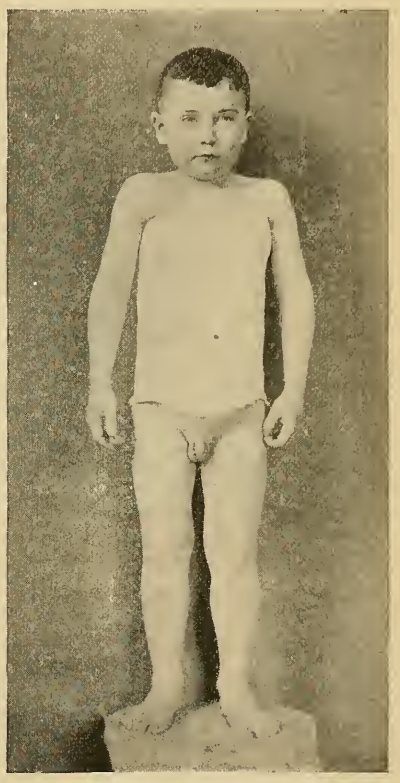

FIG. 61.—Plaster Jacket. (Children's Hospital Report.)

The abdominal pad is then removed, and the edges of the jacket are smoothed down and cut off if they press uncomfortably on the thighs or axillæ.

It is important that the jacket should be strong in front as well as behind, and should be wound as high as possible in front, in order to prevent the spinal column from falling forward. If the jacket become broken or softened, it should be removed and another applied.

Chafing can usually be prevented by careful padding on each side of the prominent vertebral process. For this purpose saddler's felt, cut of the appropriate thickness, and sewed to the undervest in the proper place, will answer.

If the disease is in the cervical region, the plaster bandages can be carried up around the back of the head and neck and under the chin, leaving the face and upper part of the head exposed, and so fixation and support may be obtained in that part of the vertebral column. This method of fixation has certain manifest disadvantages in lack of cleanliness, clumsiness, and unsightliness, but it is thorough and furnishes an excellent support and is by no means uncomfortable for the patient.

With the proper application of the plaster jacket began a new era in the treatment of Pott's disease, and for this, much honor is due to Dr. Sayre, who was so influential in bringing this useful measure to the notice of the profession. It brought a ready means of treatment within the reach of thousands of patients who could not have been helped by the prevalent methods of treatment.

Application during Recumbency on the Face.—The patient is laid prone with the arms above the head on a hammock, which consists of a stout cloth a little wider than the child, stretched over the ends of a rectangular gas-pipe frame. One end of this cloth is attached to the upper end of the frame and does not move. The other end is attached to a movable bar connected with the other end of the frame by a rope. By a ratchet this bar can be pulled upon and the tension of the cloth regulated. The hammock may be made very tight or allowed to sag to any extent. In this way hyperextension of the spine may be produced as desired.

The child is laid on the hammock, prepared as described above. The cloth is cut along the sides of the child's body longitudinally and the parts not under the child's body are drawn aside and fastened. The plaster rollers are then applied, including both child and hammock. Just before finishing the hammock should be cut across just above the top of the jacket, and the child suspended by the arms or head by an assistant and the upper turns put on with the upper spine hyperextended. This prevents the falling forward of the upper part of the jacket, which will happen otherwise. Portable frames of gas-pipe may be made for this method of application. This method has several advantages. It places the spine in a better position than does suspension and diminishes the kyphus. This has been demonstrated by Brackett.[1] It is less terrifying to children, and fainting does not occur as in suspension. The hammock frame can easily be taken from place to place. It is not so available for cases with much lateral curvature as suspension. Plaster

[1] Trans. Amer. Orth. Assn., vol. viii., p. 160.

jackets may be split, furnished with lacings and applied and removed at will; they lose thereby a part of their efficiency, as they may be improperly reapplied by the patient.

But with careful parents and attention plaster jackets lose but little of their efficiency if they are carefully split down the front and removed before they dry. If they are cut they should at once be placed in the same shape that they were in before removal and tightly bandaged to keep them from warping, as they will do if let alone.

The most acceptable form of jacket is one applied over a seamless woven shirt. These shirts are made very long and reach the knees; one of them is put on the patient and the jacket applied over it. The lower

FIG. 62.—Method of Applying a Plaster Jacket in Recumbency. (Children's Hospital Report.)

part of the shirt is then turned up over the outside of the jacket and reaches to the top of it. It is there stitched to the upper part of the shirt along the upper edge of the jacket. This, however, is not done until the jacket has been removed, by splitting it down the front and gently springing it open. The edges of the cut are stitched with leather and a row of hooks is provided on each side with which to lace it together. A jacket is thus provided, which is covered inside and outside with soft woollen material, which can be removed for purposes of cleanliness and reapplied to the patient, who should be, of course, suspended or laid on the face for each reapplication.

As a substitute for plaster jackets, corsets are made of leather, felt, wood, aluminum, celluloid, papier-maché, silicate of potash, etc. The plaster jacket, which is applied in the usual way, is removed with care, so as to preserve its shape. A plaster mould is taken, and on this as a form a corset is made of leather (which when wet can be stretched tightly over the form), by winding bandages or strips of paper soaked in

silicate of potash or paste about the mould. After this has become hard, it can be split and furnished with eyelets and lacings; it can then be applied on the patient, who is suspended, as in the application of a plaster jacket.

Rawhide stretched over a cast, thoroughly dried and left until hardened, furnishes a corset which is both light and firm. The process of manufacture requires attention and detail. The same is true of a jacket made of strips of sheet celluloid partially softened in acetone. Both of these corsets curl unless equally dried, before using, on the inner and outer side. Gauze soaked in a paste made by dissolving celluloid in acetone is serviceable, and made without great difficulty. The jacket which the writers have found to be the most readily made is of a dry leather oxhide, dressed so as to be freed from oil, stretched over a cast after being made soft by soaking, and when dried, stiffened by melted bayberry wax.

FIG. 63.—Paper Jacket. (Children's Hospital Report.)

In the upper dorsal and cervical region it is necessary either to add to the plaster jacket an appliance for securing the head (the varieties of which will be mentioned later), or to carry the plaster jacket over the shoulders and neck.

A plaster collar applied simply to the neck, and not to the trunk, does not give sufficient support except in disease of the upper cervical vertebræ, though it has been occasionally used.

The jury mast consists of a bent rod of steel running up from the jacket, following the curve of the neck and head to a point above the top of the head. To the end of this rod is attached a cross bar which carries a head sling. The lower end of the jury mast terminates in a metal framework, which is incorporated in the jacket. By raising the head sling the head can be pulled upward. But it is very difficult in practice to keep up continuous traction on the head in this way, and the inconvenience and unsightliness of the apparatus are objectionable.

The chief objection to the treatment of caries of spine with a permanent plaster jacket is in the uncleanliness. Removable jackets and corsets are not firm. As a base for head supports in the upper dorsal and cervical regions a corset is not readily applied and is more unsightly than a well-fitted appliance; but in the mid-dorsal and upper lumbar region

the permanent plaster jacket must be regarded as the most efficient ambulatory fixative appliance.

When a lateral deviation of the spinal column is present with Pott's disease, the jacket is preferable to any brace.

In disease which is very low down, the jacket is often a more efficient and comfortable mode of treatment. For careless and ignorant patients a jacket which is not removable is far preferable to any apparatus which they can misuse. Moreover, the cheapness of the jacket brings it within reach of many people who would otherwise have to go without treatment.

Treatment by Steel Appliances.—The basis of ambulatory treatment of Pott's disease in the subacute or convalescent stage is fixation of the

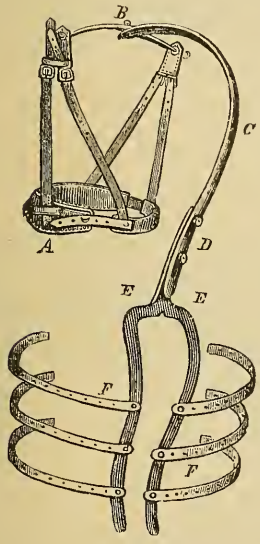

FIG. 64.—Jury-mast before Incorporation.

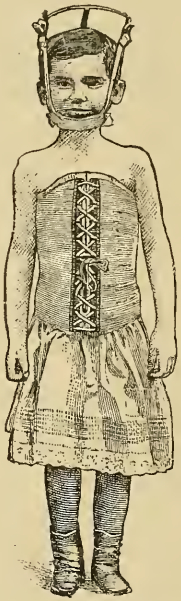

FIG. 65.—Jury-mast and Plaster Jacket.

spine in as advantageous a position as possible. This is done by means of stiffened corsets, but can also be done by means of a properly made appliance.

As the chief motion of the spine to be guarded against is the forward motion, the principle of the appliance is that of an antero-posterior support. This was first efficiently applied by Dr. C. F. Taylor, of New York, as a method of thorough treatment, as it involves skill and anatomical and pathological knowledge.

The construction and application of a brace should be superintended directly by the surgeon, and not relegated to an instrument-maker. The details relative to the future result are fully as important as the applica-

tion of a splint in any fracture, for the result will, in a great measure, depend on the accuracy of adjustment. For the construction of a splint a cardboard tracing of the back should be made.

The simplest antero-posterior apparatus consists of two uprights of annealed steel, three-eighths or one-half of an inch in width and thick

FIG. 66.—Bivalve Plastic Splint for Pott's Disease. (H. L. Taylor.)

enough to be rigid. The gauge numbers of the steel as to thickness should be from eight to twelve. These uprights should reach from just above the posterior superior iliac spines to about the level of the second dorsal vertebra. The uprights are joined together below by an inverted U-shaped piece of steel which runs as far down on the buttock as possible without reaching the chair or bench when the patient sits down.

As a guide to this it should be remembered that they must not extend down as far as the tuberosities of the ischium. Or the brace may end in a waist-band. The uprights are joined above by another U-shaped piece, the upper ends of which should pass over to the anterior aspect of the shoulders, or rather to the root of the neck. In most cases a cross bar at the level of the axillæ should be added.

The uprights should be far enough apart to support the transverse processes of the vertebræ, and not the spinous processes. They should be bent according to a cardboard tracing of the back, taken as described, and then adjusted to the back. The neck and bottom pieces should be cut out in cardboard in pattern. The whole should then be riveted together and tried on the patient, who should be lying on his face. Any alteration necessary in the curves of the steel, in order to have the appliance fit closely to the back along its whole length, can be made with wrenches. The brace can be wound with strips of Canton flannel, faced with hard rubber, covered with chamois, or covered smoothly with leather. An accurate fit is essential, the covering is merely a matter of detail

FIG. 67.—Bivalve Splint. (H. L. Taylor)

Accurately fitting pad plates covered with felt and leather or hard rubber are needed. In some instances, at the points of greatest pressure the bars of the brace, if well padded, answer every purpose. Buckles are needed at the ends of the neck piece, at a level with the axilla, opposite the middle of the abdomen, and at the lower end of the brace.

If properly designed the appliance will press firmly at the deformity,

i.e., the pad plates and pressure should be uniform at this point and closely fitted to the contour of the deformity in all planes. The appliance will also touch necessarily at the top and bottom, but the chief pressure should be at the kyphus. Variations from this type of construction will naturally be of use. Nicety of workmanship in the manufacture of a brace is of relatively secondary importance. The essential is that it should be mechanically efficient in meeting the indications of fixation. The construction of the brace does not necessarily involve expensive workmanship, and need not be anything beyond the skill of a village blacksmith. It should be borne in mind

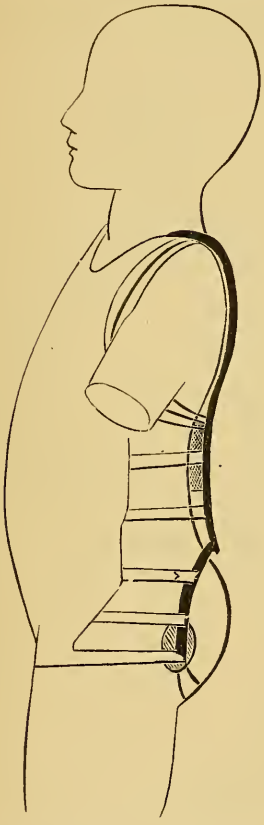

FIG. 68.—Diagram of Antero-posterior Support; Side View.

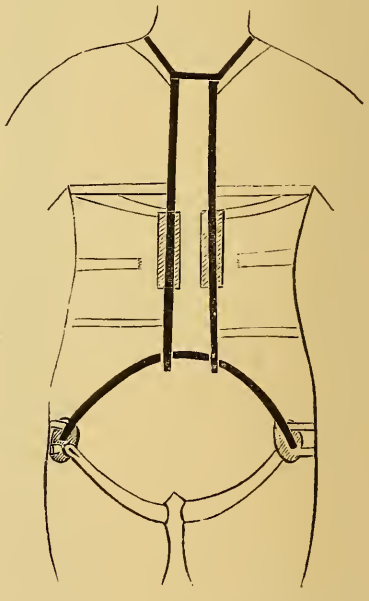

FIG. 69.—Diagram of Antero-posterior Support; Back View.

that, besides accuracy of fit and proper design, it is of importance that the apparatus be stiff enough not to yield as the weight of the trunk falls upon it, inasmuch as yielding involves intervertebral pressure. This is true not only of the uprights, but also of the band. A stiff appliance, if properly fitted, can be made as comfortable as a yielding one, and is much more efficient.

An error in accuracy of fit may be sufficient to furnish insufficient protection and cause relapse. Moreover, it is necessary that the patient

should be seen often enough to keep the brace fitting accurately, for the deformity may increase or diminish at any time. In such a case the brace becomes inefficient.

It is, of course, essential that the trunk be properly secured to the brace. This can be done in part by means of an apron, which covers the front of the trunk, the abdomen, and the chest, reaching from the clavicles nearly to the symphysis pubis. The apron is provided with webbing (non-elastic) straps, which are fastened into buckles attached to the brace. Padded straps, passing from the top of the brace around the arms, under the axillæ, and attached to buckles in the middle of the brace, help to secure it; but the scapulæ, being movable, cannot be relied upon alone to fix the trunk, and the apron must be furnished with straps at the top, which pass over the shoulders to buckles in the top of the brace.

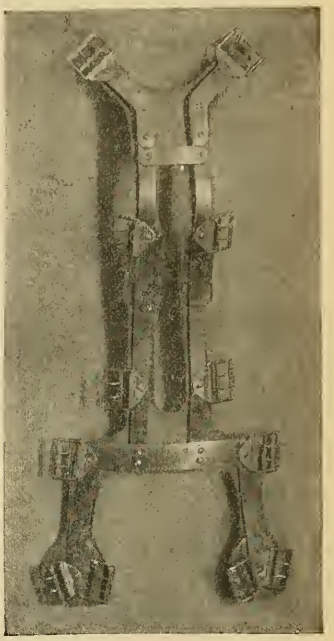

FIG. 70.—Taylor Back-brace. (Children's Hospital Report.)

In adults it is often convenient to have the apron split down the front and provided with webbing straps and buckles, so that the patient can adjust it himself by tightening the straps in front.

To secure a proper hold upon the upper segment of the body in dorsal disease some unyielding and rigid chest piece is necessary. Taylor's chest piece acts by means of hard-rubber pads at the upper part of the chest, connected by a steel rod, which keeps the brace closely against the back. The pads of the chest piece may be made of hard rubber and fit in below the clavicles, where they cause no discomfort and restrict the chest movements less than the apron, besides affording more definite support. Other forms of chest piece are in use. A simple one can be made over a plaster cast of the chest by shaping leather which is afterward stiffened by treatment with hot wax. This may be extended upward to support the chin in cases of high dorsal disease. To this hard leather, steel buckles may be attached. Schapps has described an efficient chest piece.

The brace should be worn day and night, and removed daily that the back may be bathed. While the brace is off, the patient should lie on the face or the back. On no account should he sit erect. The back, after being washed, should be rubbed with alcohol and then powdered with face powder, corn starch, or Pear's fuller's earth. The brace should then be applied and buckled tightly into place.

Chafing of the back is sometimes unavoidable in summer. When a severe chafed spot forms, the brace must be removed for the time and the child should lie flat in bed until the ulcer heals. A smooth covering of leather is least irritating to the skin. The brace may be worn over a cloth or undervest, but is least likely to chafe if applied directly over the skin.

Dr. Judson formulates a general rule which may serve as a guide in the treatment of Pott's disease by rigid apparatus, especially in all forms

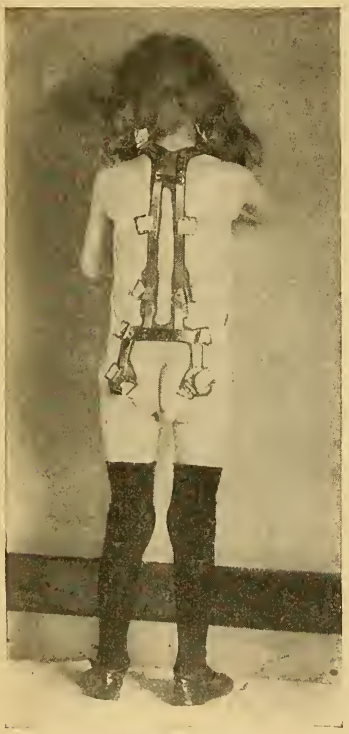

FIG. 71.—Taylor Back-brace Applied. (Children's Hospital Report.)

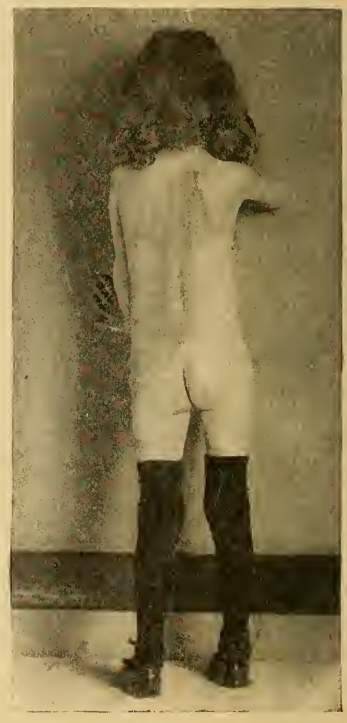

FIG. 72.—Pressure Marks from Taylor Back-brace. (Children's Hospital Report.)

of the antero-posterior support. The rule reads: "The apparatus may be considered as having reached the limit of its efficiency if it makes the greatest possible pressure on the projection compatible with the comfort and integrity of the skin."

Certain braces have a tendency to "ride-up," and the neck pieces, instead of lying closely to the shoulders, project upward in a most unsightly way. In general, this does not occur in braces which fit accurately. Sometimes, however, it is most troublesome, and in these cases padded perineal straps can be added which are attached to the apron in front and to the lower end of the brace behind. They are, however, a

source of much annoyance to children, in urination especially, and are to be avoided if possible. The apron will sometimes be found to cut over the anterior superior spines of the ilium and also under the arms, and must be properly padded.

In applying the brace the patient should lie upon his face, and the apron be spread under him. The brace should then be placed in position upon the bare back, or upon a thin, smooth cloth without wrinkles, and the apron strapped to it as tightly as is possible. The more tightly the two are strapped together, the more thorough is the

FIG. 73.—Apron for Taylor Back-brace. (Children's Hospital Report.)

fixation. The position of the straps and their number will vary in cases according to the situation of the disease, etc. The brace must of course, if it is to exert pressure, always be straighter than the spine.

A troublesome complication in the use of the antero-posterior brace is the presence of a lateral curve in the vertebral column; this has been mentioned as an occasional complication of Pott's disease. The brace fits when the child lies down, but when he sits up, the column leans to one side again, and it is of course impossible for the brace to fit as before. Fortunately, this symptom passes slowly away as efficient support is afforded to the column, and then the brace fits again. Meantime it is best to apply the brace, bending up one neck piece and bending the other

down to make the top of the brace set squarely, or to apply a plaster jacket, which is ordinarily the most available mode of treatment under these conditions; it is also best to keep the patient in a recumbent position as much as possible until the deformity improves.

The application of the therapeutic principle of fixation in the best possible position varies according as the disease involves the upper, middle, or lower parts of the spinal column.

In the upper region, as elsewhere, it is desirable to prevent the weight of the head from falling upon the diseased bodies of the vertebræ.

An efficient arrangement is one used by Dr. C. F. Taylor, of New York; an ovoid steel ring passes around the neck, made so that it can open, and be secured when closed, and arranged so that it can serve as a rest for the chin, and so that pressure can also be exerted on the occiput. This collar has at the front a hard-rubber chin piece accurately shaped to the chin, and may have at the back a stiff piece of sole leather projecting up

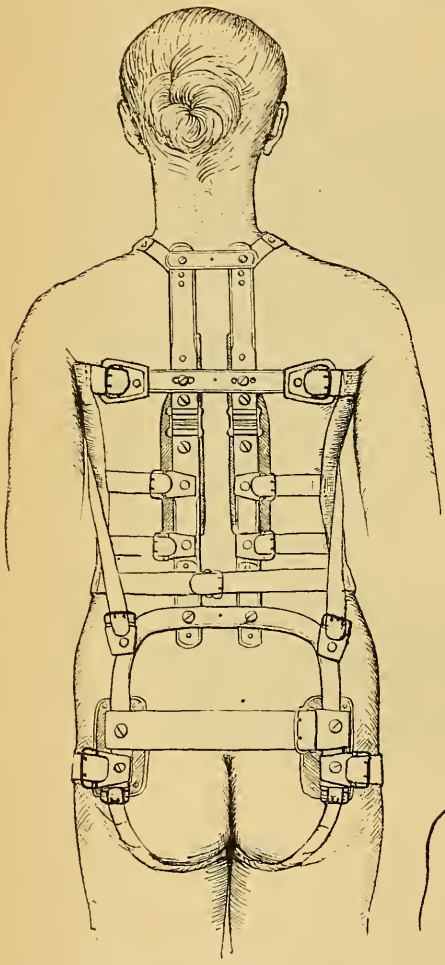

FIG. 74.—Antero-posterior Support Applied. (Dr. H. L. Taylor.)

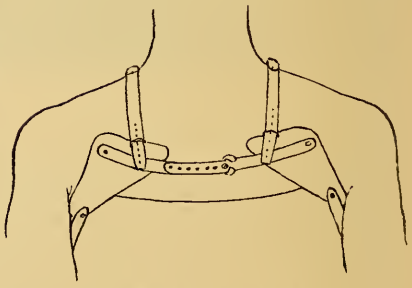

FIG. 75.—Taylor's Chest Piece.

from the back of the ring. This steadies the head and prevents the pressure of the occiput against the back of the headpiece. This collar at the back plays on a pivot, allowing lateral motion of the head. The pivot is attached to the usual back brace, and can be raised or

lowered, as it is desired to increase or diminish the upward pressure on the head. This appliance requires care and skill in application, and is useless unless properly fitted.

Other forms of head support have been tried from time to time. Some of them have been useful.

A head support, devised by Goldthwait, affords excellent fixation. Its construction is evident from the figure, and it is serviceable in cases in which there is excessive sensitiveness of the spine, due to cervical or very high dorsal disease.

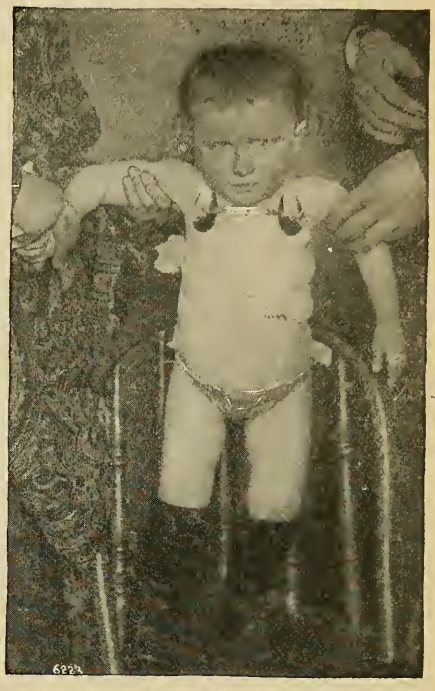

FIG. 76.—Taylor Back-brace Applied, Showing Chest Piece. (Children's Hospital Report.)

Collars of various sorts, unattached to any other appliance, have been used, which, pressing on the chin and occiput above, and on the clavicles, sternum, and shoulders below, transfer the weight in part from the intermediate cervical vertebræ and check the forward bending of the cervical region. These collars can be made of plaster-of-Paris, but are cumbersome and unsightly. The most easily made collar is that invented by the late H. O. Thomas, of Liverpool. Leather stuffed with sawdust is the most available material of which to make them. They may also be made of tin, silicate of potash, wire netting, or any of the other materials mentioned in speaking of corsets.

A convenient way of making these collars is by taking a piece of stout webbing, long enough to go loosely around the neck, and winding it with sheet wadding or oakum until it is padded sufficiently. Then it should be covered with a bandage outside, and the ends of the webbing should be buckled together. The patient wears the collar a few days, and then as the padding becomes matted down new padding is added until the collar is the desired size and shape. It is then sent to a harnessmaker to be covered with leather. In this way a much more satisfactory result is obtained than by sending measures to a harnessmaker in the first place.

In all forms of head supports, if worn for a long time, a certain amount of recession of the chin takes place. The nature of this is not clearly understood, but the growth of the lower jaw is in a measure tem-

porarily interfered with, and the front teeth in the lower jaw in severe cases do not articulate with those of the upper. The distortion results from the continued use of any form of head support, and is more liable to occur the more efficient the support. The jaw gradually resumes its shape after removal of the head support.

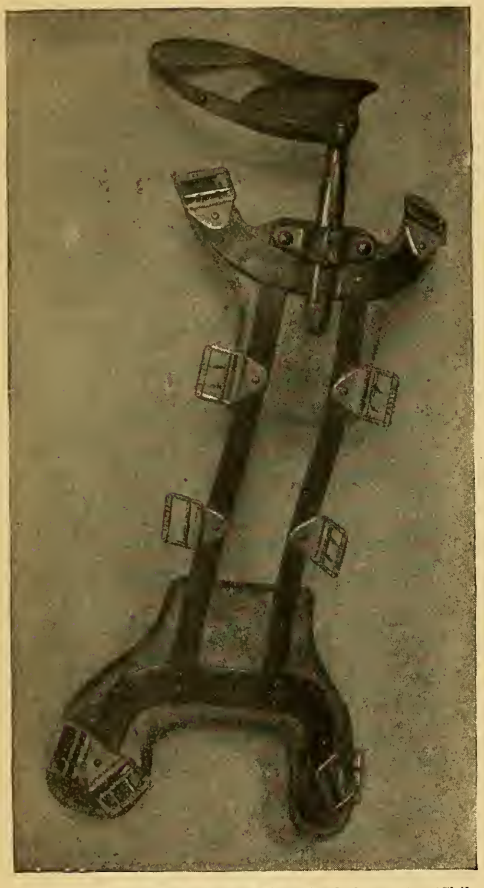

FIG. 77.—Taylor Back-brace with Head Support. (Children's Hospital Report.)

Collars, however, lack in steadiness, and, in order to secure accurate fixation of the head, they should be connected with uprights which extend below and are attached to the trunk. They are adapted only to the treatment of cervical disease of a character not very acute. When torticollis is present as the result of irritation, treatment by recumbency is advisable.

It is hard to say just when the need for a head support begins. In general, if the disease is above the fourth dorsal vertebra, a headpiece is indicated. Sometimes, if the disease is lower down, pain or distortion makes it evident that a head support is needed there also, or it may be necessary to add one if the brace does not make satisfactory pressure at the seat of deformity.

Selection of a Method of Treatment.—In the selection of mechanical supports the choice will lie between some of the fixed corsets of plaster-of-Paris (or the variations of that form of corset fixation) and the antero-posterior supports of steel.

When careful and skilled attention can be applied to the construction, attention, and needed alteration of a brace, it will be found of great efficiency in the treatment of Pott's disease in the convalescent stage. It should be remembered, as has been shown, that it is impossible to pry the vertebræ apart by leverage, as no apparatus could be worn which

would sustain absolutely the weight of the upper part of the trunk from falling forward. The antero-posterior support is to be regarded as an apparatus which modifies rather than relieves intervertebral pressure by the principle of leverage.

The chief objection to the use of mechanical appliances as a method of treatment is, that care and special skill are required, not only in the application of braces, but in the inspection and management of the cases.

Faulty Appliances.—Unless an appliance works in the way the indications of the disease demand, it is inefficient, and it is on account of

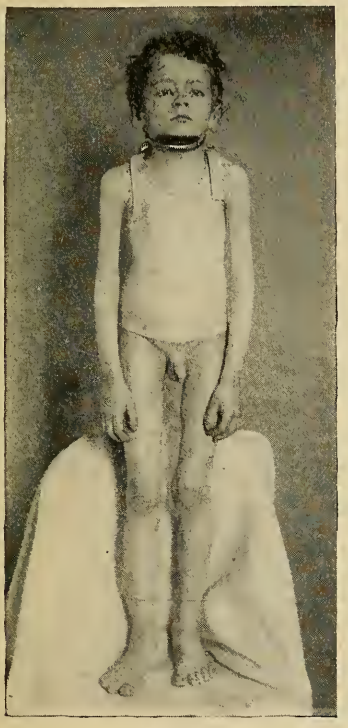

FIG. 78.

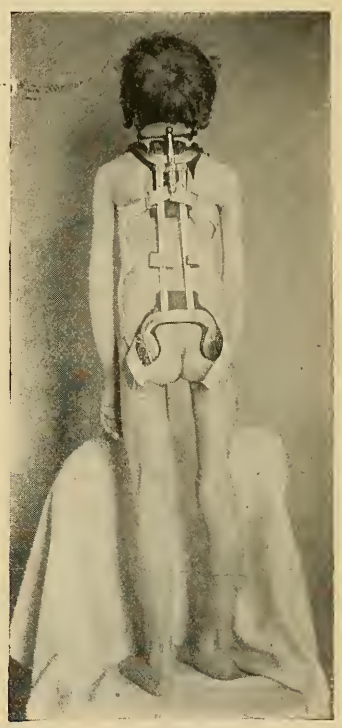

FIG. 79.

FIGS. 78 and 79.—Taylor Back-brace with Head Support Applied. (Children's Hospital Report.)

faulty construction that appliances have often been found of so little use. A most common fault is that, in order that the appliance may be light, the steel uprights are flexible and give under pressure. It is evident that any appliance which allows bending forward of the spine at the point of disease does not relieve the pressure when relief is most needed. A second fault is that the trunk is often not thoroughly fixed by the straps, etc., of the appliance. If this is the case, the brace becomes simply a splint of steel laid upon the back, and not a therapeutic agent.

The exact situation of straps must vary; they should, however, make pressure as high up and as low down on the trunk as possible. If elastic straps are used, the value of the appliance is impaired in proportion to the elasticity.

Operations on the Diseased Vertebræ. — Operative measures have been recommended for the direct examination of the diseased vertebral bodies and the removal or drainage of the diseased bone. It must be remembered that in any event the vertebral bodies are more or less inaccessible, and that such operations are not likely to prove of benefit as routine measures.

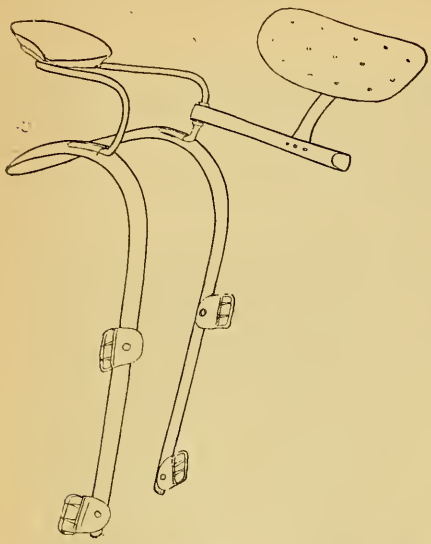

FIG. 80.—Form of Head Support for Cervical Caries. (Goldthwait.)

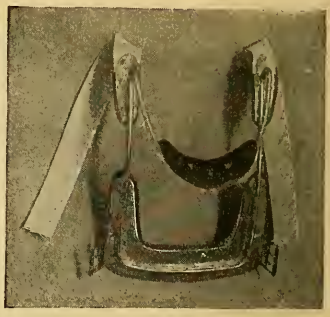

FIG. 81.—Bent Wire Chin Support. (Children's Hospital Report.)

In the cervical region the anterior surfaces of the bodies of the vertebræ may be reached either through the mouth, by a lateral incision, or by incision in the back of the neck. Through the mouth the operating space is small, the proceeding difficult on account of the anæsthetic, and the dangers of infection are evident. This method makes accessible only the second, third, and fourth vertebral bodies. The lateral method is preferable. An incision is made along the posterior border of the sternomastoid muscle; the sternomastoid and omohyoid are raised and the space made by the splenius and omohyoid is

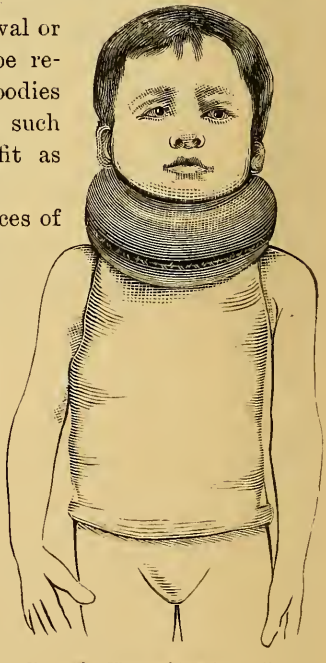

FIG. 82.—Thomas' Leather Collar.

reached. The dissection is carried through the longus colli, and the vertebral arteries are avoided.

A second method of reaching the cervical vertebræ from the side is by an incision at the level of the larynx, passing down to the lateral edge of the thyroid body close to the larynx, and dividing the tissues internal to the common carotid artery.

The incision behind the sternomastoid muscle is to be preferred.

In the dorsal region several methods have been proposed for reaching the vertebræ. Schaeffer's incision is on a line with the side of the

FIG. 83.—Young's Head Support. (Young.)

FIG. 84.—Severe Deformity in Pott's Disease, Showing the Sinking Forward of the Upper Segment Uncontrolled by Brace.

spinous processes. It uncovers the top of the transverse processes of the affected vertebræ and the base of the corresponding ribs. The ribs are divided at the level of the tuberosities, the transverse processes are then removed, the bone having been freed from its attachments by blunt dissection.

Vincent modifies this proceeding by reaching the bodies of the vertebræ on both sides of the spinal column, boring a hole through the vertebræ and passing a drain. Menard by a transverse incision exposes the

spinal end of the rib, which corresponds to the apex of the deformity. He excises the corresponding transverse process, denudes the rib of periosteum, cuts it off about two inches from its spinal end, and takes out that part of the rib. Sometimes it is necessary to resect a second rib. He follows then the periosteal canal, which leads to the tuberculous focus; this is generally opened by the extraction of the rib; the focus is then washed out and drained.

In the lumbar region the procedure advocated by Treves in 1884 is the best. An incision is made from the twelfth rib to the ilium, two and one-half inches outside of the median line; the incision reaches to the border of the quadratus lumborum and the tips of the transverse processes should be felt. The dissection is carried down to the psoas muscle; some of the fibres of this muscle are detached with care from one transverse process. The finger introduced reaches without difficulty the anterior surface of the vertebral bodies. The finger can strip up the psoas muscle through this incision and explore the vertebral bodies. The vertebral canal should not be opened.

These operative procedures are rarely indicated in tuberculous disease of the spine, except to drain increasing abscesses where thorough drainage is otherwise impossible.

Abscess.—The most common and important complication in Pott's disease is the development of an abscess. Although it is found that the frequency of abscess is diminished by efficient treatment, yet its development may be dependent upon uncontrollable pathological conditions. Abscesses may be treated by expectancy or by operation.

(1) *Expectancy.*—Under proper treatment early abscesses may subside and be absorbed without detriment to the patient. Expectancy may be aided by aspiration.

When abscesses increase rapidly, or for any reason seem an injury to the patient, incision is to be considered.

(2) *Operation.*—Incision of an abscess should be made under thorough aseptic precautions, and if these are thoroughly carried out and complete drainage secured, the procedure is devoid of undue risk; but it must be remembered that owing to the depth of the origin of abscesses in Pott's disease perfect drainage is not always as easily furnished as in more superficial abscesses. It is therefore desirable, especially in adults, to delay incision longer than would otherwise be surgically indicated.

In retropharyngeal and cervical abscesses, however, this is not true, as drainage can ordinarily be readily secured. In dorsal abscesses an incision in the back is frequently sufficient; but in some instances it will be necessary to perform costo-transversectomy to secure perfect drainage. In lumbar and iliac abscesses it is usually necessary, owing to the depth of their origin, to incise both in front and behind, which can be done with care without opening the peritoneal cavity.

If an operation is done with proper precautions it is attended with little risk of sepsis. It is not to be expected, however, that simple incision and drainage will close the abscess in most cases. On the contrary, their tendency is to discharge almost indefinitely, and this must be borne in mind in advocating operation when it is not indicated by pressure effects and the distention of the abscess.

The most usual place for opening psoas abscesses is in the groin or iliac fossa. Better drainage is secured if a counter opening is made in the loin. This can easily be done by carrying a urethral sound up and back from the lower wound and making it prominent in the loin and then cutting down on it. It must be remembered that communication in front of the vertebral canal may exist between the psoas sheath of one side and that of the other.

Very often an abscess which has advanced so far as to appear as a swelling in the groin may be opened in the back and a second opening in the groin may or may not be necessary. An incision is made along the side of the lumbar vertebræ just outside the transverse processes and carried down through the quadratus lumborum muscle until the abscess sac is reached. The abscess sac can usually be distinguished without difficulty and is made tense by pressure in the groin. It is evacuated by an incision at the bottom of this wound. In opening the abscess in this way at the seat of the disease it may be possible with a curette to remove a part of the diseased body of the vertebræ. This, however, must be done with very great care. To be of any use it must be thorough.

A retropharyngeal abscess is best opened by passing into the mouth a bistoury wound to within half an inch of its point with cotton, and cutting freely, using the finger as a guide. The child should be held face downward in order that the pus may not enter the trachea, and plenty of swabs should be at hand to keep the mouth clear, for the gush of pus is sometimes considerable.

Treatment of Psoas Contraction.—When flexion of one or both thighs has come on, it is not likely to diminish spontaneously, and if the condition is allowed to go untreated, such contractions may become permanent.

A permanent contraction of one or both psoas muscles with the thigh flexed is a serious deformity. If it exists on both sides, the patient can walk only with the trunk held nearly horizontal. If it is unilateral, it leads to a very serious disability, requiring in most cases the use of a crutch, for the diseased spine cannot be flexed to allow the foot to reach the ground in walking as it does when right-angled flexion of the thigh exists as a result of hip disease. For these reasons it is desirable to attack psoas contraction with very vigorous measures, which afford a prospect of averting any permanent contraction.

In the early stages the child should be put to bed on a frame. A light extension should be applied to the leg, and the pulley should be

gradually lowered until the leg is straight and the flexion gone. In cases in which the flexion has existed only a few weeks or months, this is generally easily accomplished in two or three weeks. If not, or if a more rapid method is desired in the first instance, the child should be anæsthetized and the leg straightened by force and retained by plaster-of-Paris or some retentive apparatus. If this cannot be done with the use of moderate force, it is better to divide and cut the fascia and the contracted bands—an operation which cannot often be done thoroughly subcutaneously, for there are many deep bands.

The deformity is almost sure to return if the patients are allowed to go about, and they should either be kept on a frame, or an arm should be extended down from the brace or the jacket to keep the thigh fully extended. Finally, subtrochanteric osteotomy may be necessary in severe cases, but it should not be done until after recovery from the Pott's disease.

Paralysis.—With the beginning of paralysis, or even in the case of much exaggerated knee reflexes, it is best to put the patient at once upon his back, as in this way the full development of the paralysis may be prevented and its course shortened. Recumbency and extension by weight seem at times to hasten recovery.

Traction made upon the head and legs, as described, probably adds to the efficiency of recumbency.

Forcible correction, not necessarily with an anæsthetic, offers probably the best chance of improvement in early paralysis; even in some cases of long standing it has proved of value. Under these circumstances the method differs in no way from that described. Two or three attempts should ordinarily be made before resorting to other methods.

Drugs are of little or no value, and it is not possible to attach much importance to the use of the cautery or of counterirritants.

Laminectomy.[1]—If these measures fail, operative treatment must be considered. It must, however, be remembered that the paralysis tends toward spontaneous recovery after a few months, so that ordinarily operation is not indicated in the early months of the paralysis. In the case of rapidly progressing or severe paralysis, however, the case is different. A spicule of bone or an intraspinal abscess may be the source of pressure at any stage of the disease, and in such cases of course operation is demanded. In cases of long standing in which the paralysis has become very extensive and has involved sensation, and possibly the sphincters of the bladder and rectum, the question arises as to whether the operation is likely to be of benefit, or whether the damage to the cord is not already irreparable; but in these cases the condition is so serious that

[1] De F. Willard: Trans. of Coll. of Phys. of Phila., March 6th, 1889; Annals of Surgery, July, 1889; Wiener med. Presse, 1884, 42; Ashhurst's "Encycl. of Surgery," vol. iv.; British Med. Journ., August 11th, 1888.

most patients prefer the chance of relief afforded by the operation. Each case must, however, be decided on its individual merits.

The operation consists in cutting down upon the spinous processes in the region of the deformity, the incision being slightly to one side of the centre, so that the resulting cicatrix will not be unduly pressed upon during recumbency. All the soft tissues are then stripped with a periosteal knife, until the laminæ are exposed. The spinous processes are then removed with bone forceps over the affected area. Laminectomy forceps are then used to cut away all of the laminæ covering the cord at the seat of pressure. The dura may or may not be opened. A probe is then passed up and down the spinal canal, to be sure that all pressure is removed, and the wound is dressed. The patient should be laid on the face after operation if it is more comfortable.

It may be said that resection of the laminæ of the vertebral column is an operation which is attended with a risk which cannot be stated numerically. But at the same time brilliant successes at times follow the operation, so that it holds out the hope of relieving cases of paraplegia which would otherwise have been hopeless. The operation, however, has no place in the treatment of Pott's disease until the conservative measures have been faithfully tried over a sufficient period of time—measures which in most cases will prove efficient and successful in the relief of the paralysis. Immediate improvement is not to be expected.[1]

Prognosis as to Time in Recovery.—No reliable statistics exist as to the amount of time necessary to establish a cure in Pott's disease. The disease varies greatly as to its self-limitation in individuals, and according to the situation and extent of the disease.

Necessarily there will be a difference in individual cases in the result of treatment.

Relief from symptoms is often easily obtained, but to establish a complete cure so that there be no latent disease requires protection and treatment for years.

Ketch,[2] analyzing seventy-five cases under the care of the New York Orthopedic Dispensary, found that the general time of obtaining a cure was as follows on the average: First cervical to third dorsal, twenty-five months; fourth dorsal to tenth dorsal, sixty-four months; eleventh dorsal to fifth lumbar, forty-seven months.

It may be said that, as the bodies in the cervical region are smaller

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[1] Medical Record, February 9th, 1889; Wright: Lancet, July 14th, 1888, 64; British Med. Jour., August 11th, 1888, ii., 308, 323; Glasgow Med. Jour., 1884, xxii., 65; Glasgow Med. Jour., 1886, xxv., 210; Med. Contemp. Napoli, 1884, i., 520; Lancet, July 14th, 1888, 264; Internat. Jour. Surgery and Antiseptics, October, 1888, 225; Brit. Med. Journal, April 20th, 1889.

[2] Neidert: Inaug. Address, Munich, 1886.

than those in the lumbar, the time required for self-limitation here is shorter than in the lumbar region. In the latter region, also, the superincumbent weight is a more important factor than in the upper part of the spine.

Roughly speaking, it is always possible to predict a course of treatment which shall last not less than three years and probably longer. Until one has seen the frequency with which relapses occur in cases which are apparently cured, when treatment has been discontinued too early, it is impossible to appreciate the true danger in an early discontinuance of treatment.

The occurrence of bony formation firm enough to support the column in its weight-bearing function must be a process requiring a long time for its completion, to judge from it as observed elsewhere; and nowhere is protection more urgently demanded during convalescence than in the vertebral column. This is especially true in growing children. Cases of supposed cure of Pott's disease have redeveloped symptoms at the period of rapid growth at the approach of puberty. It should especially be borne in mind that protection to the spine may be needed at this period.

Paralysis in Pott's disease shows a remarkable tendency to recover. The cases investigated by Taylor and Lovett gave the following results:

Of the 59 cases analyzed, 39 patients wholly recovered, 3 recovered in part, 5 died of intercurrent affections, and in 12 cases the termination is unknown. That is to say, in the whole number of cases in which the termination was known, 83 per cent recovered wholly from the paralysis. The termination was unknown in so many cases because they came only for consultation, or disappeared from observation after a little while, or were discharged for neglect. The bladder and rectum were noted as having been paralyzed in 8 cases, and here the percentage of recoveries fell to 57, in the cases in which the result was known. The arms were affected in 3 cases. Of these, 1 patient recovered wholly and the other 2 partly. Muscular rigidity is noted in 5 cases, of which 2 patients recovered wholly; but it was undoubtedly present in many others. When the paralysis came on while the patient was under treatment (19 cases), the percentage of recoveries was 100 in the 17 cases in which the termination was known. The average duration of the paralysis in all these cases was a little less than one year. When the paralysis came on under treatment, the average duration was only seven months. The disappearance of the paralysis was gradual. In 3 or 4 cases the recovery followed in a few days or weeks after the evacuation of an abscess, and in 1 case the recovery was sudden and occurred during an attack of measles, after the paralysis had lasted two years. A recurrence of the paralysis was not uncommon, having occurred in 6 cases—4 patients had two attacks,

and 2 others had three. The intervals between these recurrences varied from a few weeks to some years. Many cases of improvement or cure of paralysis have been reported after forcible correction.

Recovery may take place after complete motor paraplegia even with marked sensory impairment. Paralysis of sensation may be complete and yet recovery result, as in a case in the experience of the writers in which the loss of sensation was so great that a bandage was accidentally pinned to the skin without pain to the patient. Complete recovery from paralysis of sensation and motion, however, occurred in a year. But paralysis of sensation, especially if combined with paralysis of the rectum and bladder, makes the prognosis less favorable.

Prognosis is necessarily made much less favorable by the existence of amyloid disease of the viscera, which frequently follows long-continued suppuration.

Although the prognosis in Pott's disease is, as in all diseases, in a measure uncertain, it is possible to promise almost certain improvement from proper and careful treatment, and in most cases to anticipate ultimate cure. The final course of the disease must in many cases remain uncertain, but it is the experience of the writers that the uncertainties of prognosis are no greater in this than in other grave chronic disorders.

Treatment must be thorough and long continued in all cases.

Summary of Treatment.

The proper treatment of Pott's disease is not the application of any method, the use of any corset or brace, but the employment of such means as are most efficient for carrying out the object aimed at. A brace is useless in the case of persons unable to adjust it; a plaster jacket applied about the trunk is useless in disease of the cervical or high dorsal region. Recumbency, carried to a point of depressing the patient's mental and physical condition, is as much of a mistake as to drag a patient about who is anxious to lie down.

In the treatment of these cases, the surgeon should be familiar with the advantages to be gained by all methods, and should employ each as the case may demand, and for such a length of time as the circumstances of the case may require, or combine the different methods as may be advisable.

In a general way he may formulate to himself that: in acute, painful cases absolute recumbency with fixation, combined with traction, is the best method until the active stage of the disease is passed; in middle and lower dorsal Pott's disease an immovable plaster jacket, without head attachment, in the case of negligent people.

In disease of the cervical, dorsal, and upper lumbar regions some form of fixation appliance must be used if the patient is not recumbent.

The choice will be directed by the circumstances of the case (amount of care, expense, sensitiveness as to appearance) between a plaster bandage, collars, braces, etc.

In the lowest lumbar region recumbency, with or without fixation by extension, constitutes the most thorough method of treatment. Braces or corsets are of value as a help in these cases for fixation during recumbency or in the stages of convalescence, and when recumbency is unadvisable.

When a curve is marked attempts should be made to correct it in cases in which bony ankylosis has not taken place, either by gradual means or the application of moderate force, followed by fixation in a corrected position, with recumbency.

In the convalescent stage fixation is to be continued until cicatricial ostitis has restored the structure of the vertebræ to a normal degree of resistance.

Properly constructed braces, designed so as to apply thorough anteroposterior support, with fixation in an improved position, form a method of treatment most satisfactory to the surgeon capable of controlling and inspecting his patient. For such treatment, however, care on the part of the attendant of the patient, and ready facilities for the adjustment of braces, are necessary.

Whether recumbency for a time is required, or whether ambulatory treatment with fixation appliances is sufficient, are questions of judgment in individual cases.

CHAPTER II.

LATERAL CURVATURE OF THE SPINE.

Definition.—Frequency.—Predisposition as to sex.—Clinical history.—Stages of the affection.—Symptoms.—Varieties.—Etiology.—Pathology.—Diagnosis.—Prognosis.—Preventive measures.—Treatment.

By this term is understood a constant deviation of the spinal column, or a portion of it, to either side of the median line of the body, with a resulting distortion of the trunk. The affection has also been called scoliosis, and rotary lateral curvature.

In French it is known as *Scoliose, déviation latérale de la taille,* and in German it is called *Seitliche Rückgratsverkrümmung.*

Lateral curvature is either congenital or acquired. The former variety, however, is rare; when present, it is either a result of fœtal rickets or it is an accompaniment of imperfect development, and inequality in the formation of the different sides of the trunk.[1]

Ketch,[2] generalizing from 229 cases, concluded that lateral curvature usually begins from the 8th to the 15th year; in 52 per cent of the cases the distortion began between the 1st and 12th year. In 41 per cent from the 12th to the 18th, and 3 to 4 per cent from the 18th year upward.

Eulenburg, in 1,000 cases, noted:

78 between birth and the 6th year.
216 " the 6th and 7th years.
564 " " 7th and 10th years.
107 " " 10th and 14th years.
35 after the 14th year.

The Frequency of the Deformity.—The frequency of scoliosis may be estimated by Drachmann's figures, who found in 1884, on examining 28,125 school children in Denmark (16,789 boys, 11,386 girls), 368 cases of scoliosis, one and one-third per cent. Fisher states that of 3,000 cases of deformity brought to the National Orthopedic Hospital of London 937 were affections of the spinal column, and 353 were lateral curva-

[1] Vogt: "Moderne Orthopædik," p. 75; Schreiber: "Orthopædische Chirurgie," p. 118.

[2] New York Medical Journal, April 24th, 1886.

ture. Berend reports 900 scoliotic patients in 3,000 patients; Langgaard, 700 in 1,000 cases; Schilling, 600 in 1,000 (Schreiber). These figures, however, taken from foreign authorities, do not necessarily represent the numbers to be found in American hospitals.

Predisposition as to Sex.—The distortion is more common in girls than in boys, and in the proportion of from four or five to one.

Ketch found 189 females and 40 males.

Kölliker found 577 females and 144 males.

Bernard Roth found in 200 cases, 183 girls; Wildberger, out of 120 cases, 101 girls; Berend in 896 cases, 773 girls.

Out of 173 cases collected by Adams, 151 were females, 22 were males.

Drachmann found the proportion of girls to boys, that of eight to two.

But of the most severe forms of the disease there are more males than females, and it is possible that if parents were as solicitous as to slight variations in the figures of their boys as of their girls, the statistics would show a greater proportion among boys than has been reported. In the lateral curvatures of young children (under five) the males are said to equal or to outnumber the females.

Clinical History.

It should be distinctly borne in mind that lateral curvature is not strictly a disease so much as a distortion of growth.

The deformity appears and is developed during the growing years; becoming arrested, as a rule, at the end of the period of growth.

The affection may be divided into three stages:

1. Initial stage.
2. Stage of development.
3. Stage of arrest.

Initial Stage.—The affection is ordinarily discovered by the patient's mother at the age just previous to puberty. It has, however, been shown that it has developed earlier than this in a majority of cases, but is not recognized.

Lateral curvature is not usually seen in its earliest stage. At this period of it, the symptoms are so slight and the deformity is so easily overlooked that the surgeon is rarely consulted. The patient suffers no inconvenience at this stage, and as the child is at an age (seven to ten) when the figure is not carefully scrutinized, little attention is paid to the slight elevation of the shoulder or projection of the hip. Upon examination, but little else is to be seen, and these symptoms disappear on recumbency or suspension. Tests as to the strength of the muscles sometimes show a comparative lack of muscular force, but this is frequently

not the case. A careful examination often discloses a peculiarity in standing or sitting.

State of Development.—In a majority of cases when the surgeon is consulted, well-marked development of the distortion has already taken place. The curves are either *flexible* curves, that is, nearly disappearing on recumbency of the patient, or when the patient is suspended; or are *fixed*, when little change of the curve takes place in removing the weight from the spinal column. Cases vary greatly in the rate of progress made.

The muscular system may or may not be well developed; but in a majority of cases the muscles are not large or strong.

In the early periods of the development of the affection there is rarely any symptom complained of except the annoyance of the curvature, due to a distortion of the figure. In a few instances of growing girls with marked impairment of strength, some thoracic pain may be felt, and fatigue on exertion in walking or standing. In addition to this, sensitiveness and burning sensations in the back may be found, though these latter are more properly attributable to a disordered condition of the nervous system, classed as neurasthenia, than directly to the lateral curve.

The period during which the curvature of the spine may develop is indefinite, as well as are the rate and extent of the development. It is impossible, in the present stage of our knowledge, to predict the amount of increase or the permanency of arrest.

The liability to increase is greatest during the growing years. But cases of severe curvatures will be seen in which development has slowly continued during the years of younger adult life.

Stage of Convalescence and Arrest.—While it is certainly true that the time when a curve may be regarded as arrested is not easily recognized, an examination of a large number of untreated cases justifies an opinion that spontaneous arrest takes place in a very large number of the slighter cases, without further development of the deformity. Even in many of the severer types of the deformity patients will be observed who go through adult life without any increase of, or inconvenience from, the deformity.

No sharp distinction as to stages of development and arrest can be made, but the classification of this sort has its value in considering treatment.

In general, it may be said that the initial stage corresponds to childhood and the approach of puberty; the stage of development extends from the period of commencing puberty to the establishment of growth; and the stage of arrest, or quiescence, includes a period after completion of osseous development.

Symptoms.

Pain. The symptoms depend, in general, upon the amount of distortion, but this rule is not an absolute one, as in certain individuals slight irritation produces a greater amount of pain than in others less deformed. Painful symptoms are as a rule not common in the affection.

Fig. 85.—Right Lateral Curvature. (Weigel.)

The symptoms of pain are of three classes:

1st. Those due directly to the altered muscular or ligamentous strain.

2d. Those due to the abnormal pressure from distorted ribs or vertebræ upon nerves, or to alteration of the size and shape of the thorax, and displacement of viscera.

3d. Neurasthenic symptoms from a lack of vitality, superinduced by the limitations as to exercise and activity, consequent on the deformity.

Cases of slight curves are practically free from symptoms of pain, and in the milder types of the deformity, at the stage of arrest, no symptoms are complained of if the patient is in good health; if, however, the health becomes enfeebled, slight neuralgic pain in the sides of the thorax is occasionally felt. This is usually accompanied by paræsthesia, or hyperæsthesia in certain parts of the back, in the upper dorsal or lumbar region; but in the severest types of the deformity, symptoms directly due to the distortion may be observed, viz., neuralgic pains from abnormal pressure upon nerves and from undue strain upon ligaments and fasciæ, occasioned by distorted attitudes.

The pain, which is usually located in the lumbar region and the thighs, is worse after fatigue, and is relieved in a measure by removing the superincumbent weight, but it is often impossible to determine

whether these symptoms are due directly to the curvatures or to a concomitant neurasthenia.

Tenderness on pressure is never present in pure lateral curvature, and when found it is an evidence of nervous depression.

General Symptoms.—Interruption in the functions of the liver, stomach, and intestines is mentioned by Adams as occasionally seen in severe

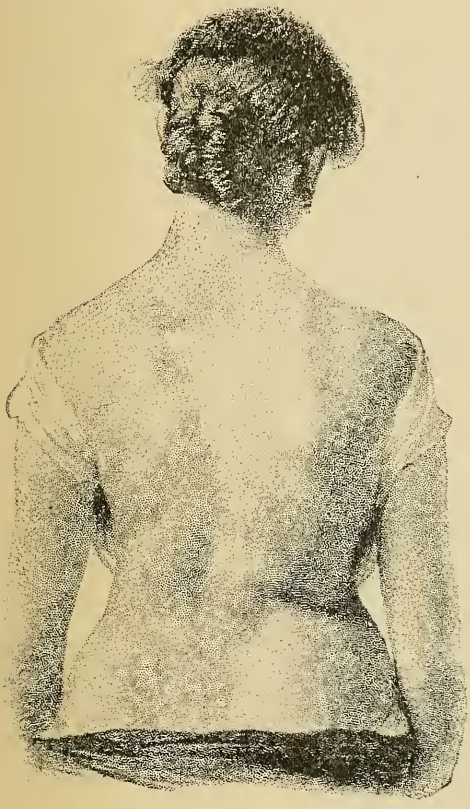

FIG. 86.—Long Right Convex Dorsal Curve.

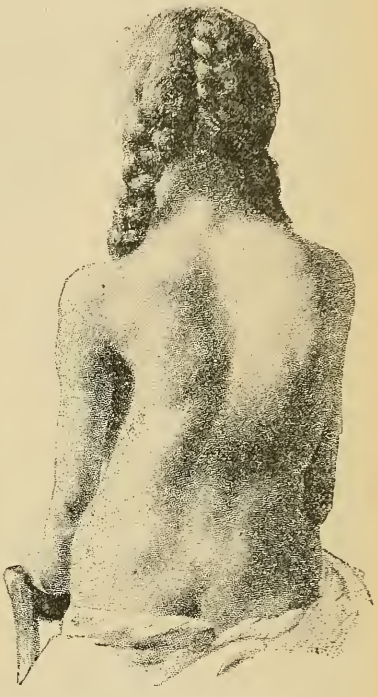

FIG. 87.—Double Lateral Curvature.

cases. Shortness of breath also occurs as well as pain in the stomach, loss of appetite, and indigestion.

In the severest cases a lack of deposit of fat in the subcutaneous tissue will be noticed, and the patients are thin, even though they may be in relatively good health.

The neurasthenic symptoms are chiefly manifested by indisposition to exertion, vague complaints of pain and discomfort, and tenderness in the back. These symptoms are rarely as marked in lateral curvature as in the pure forms of spinal irritation, but they may be added to the symptoms directly due to the distortion.

In many of the severest forms, the patients' lives are made miserable by a variety of symptoms probably referable to impaired circulation, feeble digestion, lack of energy, and limited powers of respiration. The symptoms are in part due to the mechanical compression of the deformed thorax, and in part to a lowered condition of the nervous system, as is seen in ordinary cases of neurasthenia.

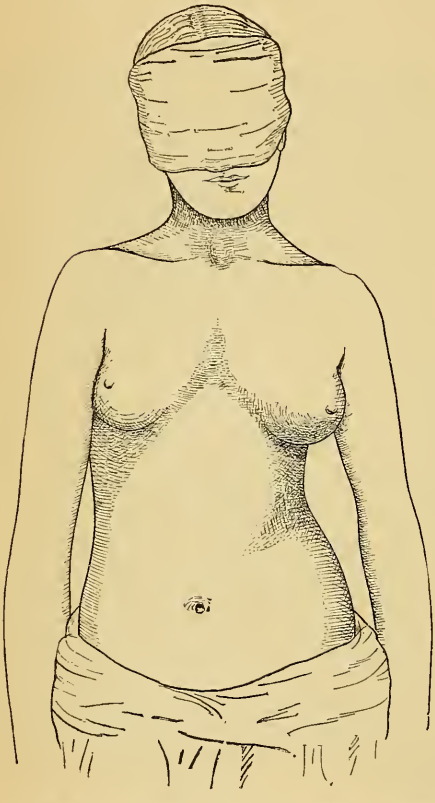

FIG. 88.—Front View of Lateral Curvature, Showing Prominence of Left Mamma in Right Dorsal Convex Curvature.

Distortion. — The chief symptom of lateral curvature is necessarily the distortion, which, even when not severe enough to occasion discomfort, is often a source of mortification and annoyance to the patient.

The distortion is not limited to a simple curvature of the spine, but, as will be described later, to this is added a twisting of the whole trunk; or, in other words, there is both a curvature and a torsion on a vertical axis.

Curvature.—The curvature of the spinal column varies in degree, situation, and extent.

The variations are so great that no two curvatures are precisely alike, as is evident from the accompanying illustrations. There are, however, common types, which it is convenient to bear in mind in considering the subject of treatment.

If one lateral curve occurs in the middle region of the spinal column, two other compensating curves are of necessity developed in opposite directions, one above and one below the deformity, in order that the head be kept erect and in the median line. These compensating curves may or may not be of pathological significance.

For practical purposes the lateral curvature consists of a single curve, which may be situated in different parts of the column. In some instances one of the compensating curves is of an equal prominence with the so-called primary curve; in which case the spinal column will present the S-shaped curve which is characteristic and which is illustrated in

the accompanying pictures. In other cases, what is termed the compensating curve may become more marked.

The curves are often termed either dorsal or lumbar, but they are rarely limited exactly to these portions of the spinal column; in most instances, also, the curves are not typical; the upper curve may be so long as to include all of the dorsal and upper lumbar vertebræ, so that the prominent hip, due to the sinking away and rotation forward of the lower ribs on the side of the concavity, may not be the right, but the left hip—although the right shoulder is raised. Again, the lower curve may be so long as to invade nearly the whole of the dorsal region, the compensation taking place in the upper part of the cervical region.

FIG. 89.—Left Lumbar Curvature, Showing Prominence of Hip. (Weigel.)

In both these varieties of curves, compensating curves, so called, are necessarily present. They may be so slight as not to attract attention, or they may constitute a curve of equal severity with the upper or lower curves, forming a double curve.

Furthermore, when the curves are in the flexible stage it is difficult to determine which is the more important one; but after osseous changes have taken place, the most important curves become fixed, and these are the curves which demand most attention. This is partly due to the attitude in which the column is placed, and partly, probably, to a lack of resistance of tissues of certain parts of the spinal column.

Cervical Curvature.—The cervical or high dorsal curves are the least common forms of lateral curvature, except when associated with torticollis.

This curvature may, however, occur primarily; when it does, it is

more commonly accompanied by a long compensatory lower curve. There is invariably elevation of one shoulder and an inclination of the axis of the head to the side of the concavity of the cervical curve.

Dorsal Curvature.—The most common dorsal curve is with the convexity to the right. In these cases the right shoulder will be raised, the right shoulder blade will project backward more prominently than the left, and will be at a higher horizontal level and farther from the median line of

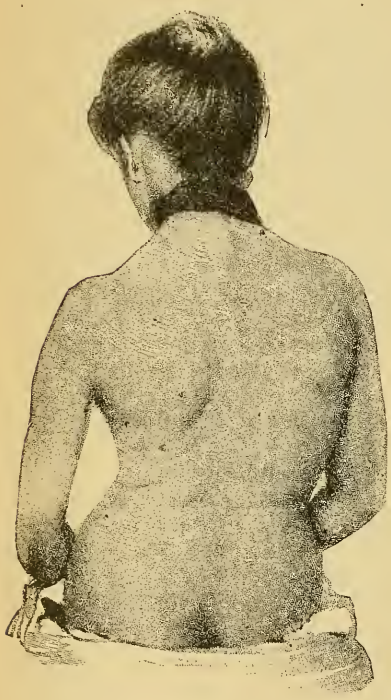

FIG. 90.—Dorsal Right Convex Curve.

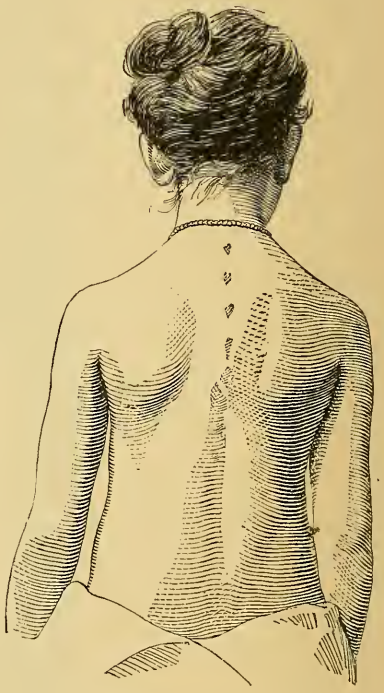

FIG. 91.—Slight Flexible Upper Dorsal Right Convex Lateral Curvature.

the trunk. The back, just below the scapula, will be more rounded backward on the right side, and more flattened on the left, and the left shoulder will be held down. In front, in well-marked cases, the breast may be more prominent on the left than on the right side.

In addition to the curve there may be a tendency to incline the whole trunk to the right side. When this is the case, the right arm, when hanging, will be free from the side, while the left arm, when hanging down, necessarily strikes the hip.

There is also, unavoidably, a change in the outline of the sides of the back. The sides, instead of being symmetrical, as seen from the back, will be different, the left side of the outline will be unnaturally straight, and on the other more than normally hollowed.

Lumbar Curvature.—The lower dorsal or lumbar curvature manifests itself by a prominence of one of the hips; most frequently the right, sometimes the left. In well-marked cases there is also a fulness in the back on the left side, above the crest of the ilium; and a corresponding flattening on the right side. In front the umbilicus is at the side of the median line. The most common lumbar curve is with the convexity to the left.

A difference in the outlines of the two sides of the back, already mentioned, is also seen in this form of curvature.

A sharp clinical distinction between lumbar and lower dorsal curves is not practicable, as they resemble each other in regard to the resulting

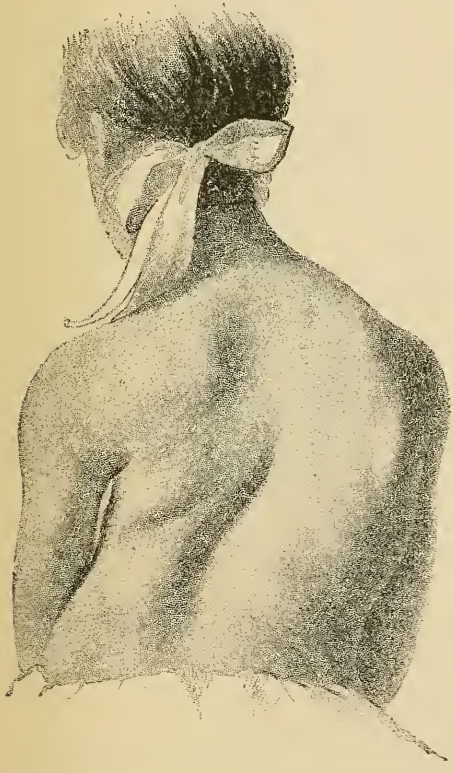

FIG. 92.—Projection of Shoulder in Right Convex Dorsal Curvature.

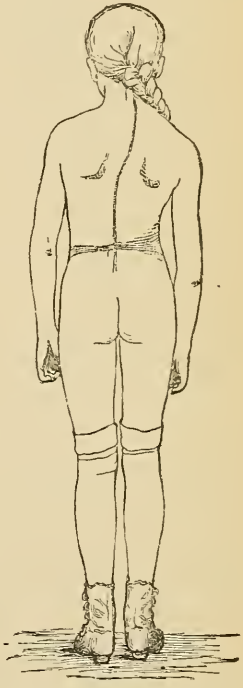

FIG. 93.—Upper Dorsal Curvature.

distortion. A combination of lumbar and dorsal curves will of course present the features of both varieties, but the distortion of the most pronounced curve predominates. If the curves are equal, a double curva-

ture is said to exist, in which case the leaning to one side is not so marked as in long, single, dorsal curves.

The more common curves are those indicated with the upper convexity to the right and the lower convexity to the left, but the curves may be reversed; when this is the case, the distortion will be correspondingly altered.

Localization.—Some writers regard the lumbar scoliosis as the chief

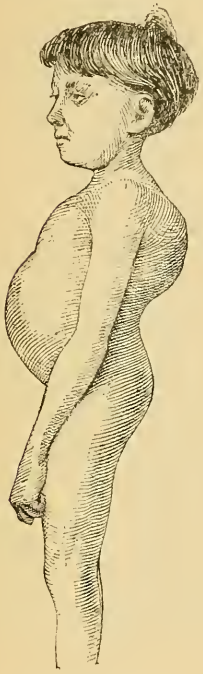

FIG. 94.—Antero-posterior Curve in Lateral Curvature.

FIG. 95.—Severe Lateral Curvature (Untreated).

curve, and as most common. The question may be regarded as not settled, though for clinical purposes it may be accepted as a fact that the dorsal curve is the one most frequently requiring treatment.

Limping.—In certain very severe cases the distortion of the vertebral column is so great that the pelvis is secondarily tilted, and by this one leg is rendered shorter than the other for practical purposes and a more or less marked limp may be caused.

In 721 cases, Kölliker[1] found that 391 were in the dorsal region; 208 of these were with the convexity to the right and 183 with the convexity to the left. Two hundred and twenty-two cases showed double prominent

[1] Centralbl. f. Chir., No. 21, 1886.

curves, and of these 172 were with the upper curve convex to the right and the lower curve convex to the left.

Forty-two and two-thirds per cent of the number examined by Drachmann, 92 per cent of those reported by Eulenburg, 84 per cent according to Adams, and 81 per cent according to Heiner, presented curves in the upper dorsal region with the convexity toward the right. Lorenz and Drachmann think that the lumbar lateral curvature with the convexity toward the left is more frequent than has been thought. Lorenz found in 163 cases 62 lumbar curves and 64 dorsal; and Klopsch found 71 lumbar curves in 121 cases. Out of 569 cases in the Royal Orthopedic Hospital of lateral curvature 470 cases presented curvature with convexity toward the right side, 99 to the left side. Of Adams' and Lonsdale's 173 cases, in 149 the convexity was to the right side, and in 24 the convexity was to the left side.

Some discussion has taken place as to which is to be regarded as the primary and which the secondary curve in cases of double scoliosis. Bouvier, Malgaigne, and most French writers claim that the dorsal curvature toward the left is the one which is first formed, and that the lumbar curve is generally much smaller, with the concavity to the right and secondary (see Malgaigne); this is denied, however, by many surgeons, notably Alexander Shaw, who considers that the lumbar curve is the primary one and that the dorsal curve is secondary. According to Schenk, the lumbar curve is the most common primarily, but the dorsal curve is most commonly brought to the attention of physicians on account of the greater deformity due to a torsion of the ribs.

Torsion.—As is explained under the head of pathology, it is impossible for any curvature to take place in the spinal column without being accompanied by torsion of the vertebræ on a vertical axis, or rotation as it is frequently termed.

The prominence of torsion in lateral curvature is a measure of the severity of the case. It is to this torsion of the vertebræ that is due the necessary alteration of the position of the ribs, the prominence of the shoulder blade as well as the flattening of the chest on one side, the difference in prominence of the breasts and of the hips, and also the lumbar fulness.

These symptoms of torsion may be present before any curvature can be determined in the line of the spinous processes, the projection of the shoulders, or of the hip, constituting the first evidence of lateral curvature.

Torsion presents the most characteristic and distressing symptom of lateral curvature, for it not only causes the projection of the shoulder and the hip—the most disfiguring part of the deformity—but it is to torsion and its consequences that the greatest contraction of the chest and resulting disturbances are due.

The amount of torsion may be much greater in some cases than would be expected by the slight amount of apparent lateral deviation of the spinous processes, as if the vertebræ yielded more by twisting under superincumbent weight than in a sideway curve.

Varieties of Lateral Curvature.

The varieties of lateral curvature are in all probability not so numerous as some writers would lead us to suppose, but as there are many different causes which may produce the distortion, a number of varieties may be readily classified.

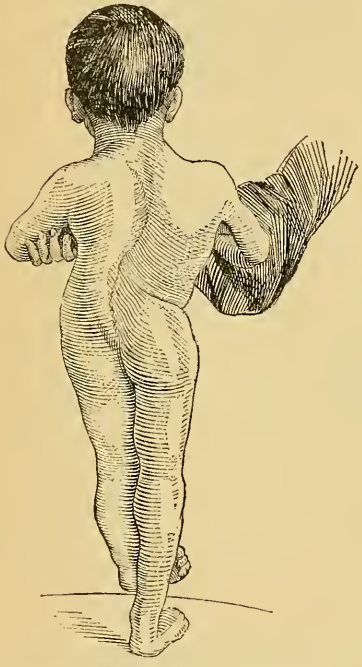

Fig. 96.—Lateral Curvature Following Marked Inequality in Length of Legs.

A lateral deviation is sometimes seen in an early stage of caries of the spine, and at the later stages in untreated or neglected cases when the consolidation of the carious bone has taken place irregularly.

The distortion may follow fracture or dislocation, and is occasionally seen in the rare affection, spondylolisthesis, described in another chapter.

In sacro-iliac disease a curvature of the spine due to the peculiarity of the attitude is quite constant, and in torticollis scoliosis necessarily follows.

Rhachitic Lateral Curvature.—This form occurs in rhachitic children; but it is not so common a curve as the antero-posterior curve which appears as a backward prominence in the lumbar region in so many cases of rickets.

The pure rhachitic lateral curvature has, according to Lorenz, its greatest curve in the middle of the spinal column, and is more likely to be characterized by convexity to the left.

Guérin claims that rhachitic children show a lateral curvature in 9.7 per cent of cases. Eulenburg found that in rhachitic scoliosis, the period of development of the curve was in the first six months in 54 per cent of the cases, and that the percentage diminished to nothing at the seventh year. The affection is as common in boys as in girls. The distortion may or may not be accompanied by other evidence of rickets, but in most cases the other signs of the disease are marked.

In some varieties of lateral curvature there may also be an exaggerated antero-posterior curve due to yielding of the bones under the unusual distribution of superincumbent weight.

Static Lateral Curvature.—This term is applied to that form due to inequality of the length of the legs.

A slight difference in the length of the lower limbs is the rule. But development of lateral curvature directly from this cause is not invari-

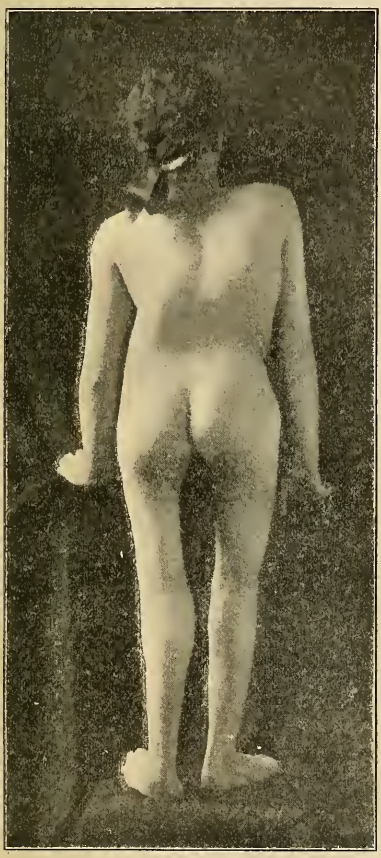

FIG. 97.—Lateral Curvature from Infantile Paralysis.

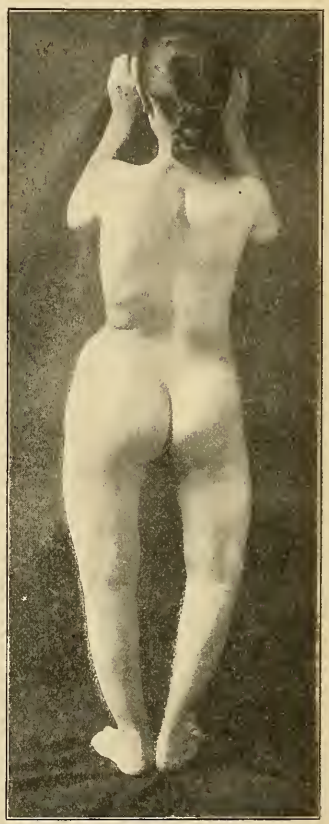

FIG. 98.—Lateral Curvature from Rickets.

able, as is evident from the fact that in a comparatively small number of cases of scoliosis a notable difference is detected in the length of the lower limbs.

Sklifosowsky found in 21 cases of lateral curvature, inequality in the length of the limbs in 17.[1] Staffel found in 230 cases of scoliosis the

[1] Centralbl. f. Chir., 1884. p. 43.

left leg shorter in 62 cases. H. L. Taylor found 28 cases of shortening of the left leg in 32 cases of scoliosis.

Furthermore, from only a comparatively small number of cases of clearly defined shortened limbs from infantile paralysis, hip disease, etc., does true scoliosis result. In a certain number of cases, however, of shortened limbs from these affections, a marked lateral curvature is found, in some cases characterized by rotation of the ribs.

That curvature should develop in some instances and not in others is probably due to the fact of the existence in certain of these cases of less resistance of the spinal column to unfavorable conditions.

Paralytic Lateral Curvature.—In a certain number of cases of paralysis of the muscles of the back lateral curvature of the spine is found.

When the muscles of the back are weak, the patient instinctively assumes an attitude in which the spine is balanced with the least action on the part of the weakened muscles. The bones of the spine may be affected (if lacking in a power of resistance) by a constant vicious attitude, and a fixed lateral curvature result.

This form of lateral curvature is most commonly developed after infantile paralysis, as this is the most common form of paralysis occurring in the growing years; but the effect of other palsies, if influential in weakening certain muscles of the back, would be the same, and the distortion may be seen after spastic paralysis, progressive muscular hypertrophy, syringomyelia, and other affections weakening the muscles of the spinal column.

Lateral Curvature from Contracture of the Chest.—Lateral curvature may follow empyema and some deviation of the spinal column almost necessarily follows severe forms of empyema. In the purest forms of this type there is no true scoliosis, the spine not being twisted to a noticeable extent, but simply pulled to one side, the ribs being flattened, *i.e.*, fixed obliquely at a lower angle than normal, from the cicatricial contraction of the lung which prevents expansion of the lung on that side and leads to an increased expansion on the other. In certain cases, however, the altered position so induced has its effect upon the growth of the spine, and a true lateral curvature with torsion takes place.

It has been said that a curvature followed in some instances pneumonia and phthisis, but this is not, according to Mr. Adams, commonly the case.

Lateral curvature in a case of sarcoma of the ribs and lung has been reported by Shattuck.[1]

Lateral Curvature from Occupation.—Lateral curvatures of severe type due to occupation are not, as a rule, so common as other forms, for the reason that laborious occupations are not, in general, entered upon

[1] Boston Med. and Surgical Journal, January 10th, 1889.

until an age when the spinal column has a sufficient amount of resistance to withstand the superimposed weight.

Slight lateral curves may be seen, similar to the kyphosis of those employed in occupations requiring stooping. Scoliosis in school children is, in fact, a curvature from occupation in a true sense, though the term as ordinarily used is not so applied. In clerks one shoulder is often higher than the other from the attitude of writing, and it is said to be true also in blacksmiths. Severe forms of this class are sometimes seen in adolescents whose occupation habitually twists the spine, as in carrying baskets or trays. Arbuthnot Lane has called special attention to this fact, and has also observed that the shape of the lateral curve varied in a measure with the occupation.

FIG. 99.—Lateral Curvature Following Empyema.

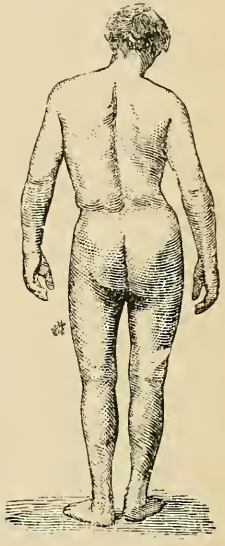

FIG. 100.—Lateral Curvature in Sacro-iliac Disease.

In short, occupations which require constant one-sided attitudes, as in the clerk, artist, blacksmith, etc., may, in certain individuals, develop a lateral deviation of the spinal column as the natural result of this constant position.

Scoliosis in nursing women, from carrying infants too frequently upon one side, is also recorded, and the same attitude in one-armed persons. Lateral curvature from a peculiar position in sitting has also been noted due to inequality of eyesight.

Ischias scoliotica,[1] referred to also as scoliosis neuromuscularis, or neuropathica or ischiatica, is a term which has been applied to lateral curvature in the lower part of the spinal column occurring in connection with sciatica. It is severest in cases in which the lumbar nerves are involved. The curvature may be to the side of the affected nerve, or the reverse, or it may alternate. The condition is most easily relieved by fixative appliances.

Physiological Curve.—What has been termed a physiological curvature has been described by Bouvier. Such a curve is usually found with the convexity to the right in the dorsal region; it is sometimes seen at autopsy, but not in young children. It is supposed to be due to the weight of the heart, or to the greater use of the right arm or right side of the body. The importance of this curve is not so great as is supposed by some writers. In fact the existence of this physiological curve has been denied by many authorities.

Flexible, Fixed, and Structural Curves.—Varieties have been made by some writers who wish to classify lateral curvatures as *flexible* or *fixed* according to their disappearance or persistence on a change of attitude. Structural curves are described as those in which a change in the structure and shape of the bones has taken place.

Etiology.

A great deal has been written on the subject of the causation of lateral curvature, and the question is still a vexed one, although at present the weight of authority favors the opinion that the deformity is chiefly brought about by mechanical influences.

The theories advanced to explain the phenomena of lateral curvature are the following:

1. That the distortion is due to unequal muscular action, as is true in torticollis. 2. That the cause is to be found in an inequality of growth of different portions of the vertebræ, as if the affection were to be classed as a localized unilateral hypertrophy. 3. That the distortion is the result of superincumbent weight acting upon a faulty condition of the spinal column.

One of the most notable causes alleged for those cases in the first group is that of active muscular contraction, which was advocated by Jules Guérin, who believed that lateral curvature was caused by the

[1] Gussenbauer: Prag. med. Wochenschr., 1890; Albert: Wien. med. Presse, 1886, Nos. 1 and 3; Nicoladoni: Wien. med. Presse, 1886, Nos. 26 and 27; Schüdel: Arch. f. klin. Chir., 1889, xxxviii.; Remak: Deutsche med. Wochensch., 1891, No. 7; Vulpius: Deutsche med. Wochenschr., September, 1895; Topp: Zeitschr. f. Orth. Chir.. 1899, vi., 435; "Ischias Scoliotica," Langenbeck's Archiv, 1889.

spasmodic contraction of certain muscles, in the same way that the head is twisted in torticollis. As a result of this belief, myotomy of muscles on the concave side of the curve was recommended by Guérin, and in one case he performed thirty or forty muscular divisions. Both this method and theory have fallen into discredit. The facts, as seen clinically, do not substantiate such a theory. In the cases of true lateral curvature at an early stage, not only is there no spasm, but no contraction even of the muscles on the concave side of the curve; and the contraction seen in the later stages of pronounced curves can be explained by the supposition of the adaptive shortening of the muscles.

It may be assumed that although in exceptional cases there may exist an active contraction of certain muscles as a cause for lateral curvature (as is the case in torticollis and in some instances of caries of the ilium or lumbar vertebræ), yet these cases are so exceptional as to be insufficient to establish a rule for the treatment of scoliosis. Stromeyer and Barwell have spoken of the contraction of the serratus muscle as a cause of this deformity. This, however, has not found general acceptance.

A much more probable presentation of the muscular theory is that which has received the able advocacy of Eulenburg and which has met with acceptance from many authorities and been the foundation of a system of treatment. The theory may be stated as follows: Continuous muscular action is necessary for holding the trunk erect. If all the muscles are not in continuous action they must be constantly on guard to prevent any deviation from the normal position. If any of the muscles are weakened, the spinal column will tend to bend, the deviation falling with the convexity on the side of the weakened muscles—the side of the concavity being that of the normal muscles. In weak individuals, habits of attitude, continued for a long time, will weaken certain muscles by over-stretching them, and will cause distortion to ensue.

The objection to this theory is that it cannot satisfactorily explain all the facts. Diminution in the strength of the muscles has in the early cases not always been evident, and such as has been found is in the severe cases only what would result from the long-continued disuse of the muscles. Furthermore, lateral curvature is often developed in individuals of apparently strong muscles. There is, moreover, no proof that muscles are weakened by the slight over-stretching which follows the habits of standing or sitting seen in children. As Lorenz has justly observed, the habits of sitting or standing on one leg should, if Eulenburg's theory is correct, develop an abnormal attitude of the hip, knee, or elbow, from muscular action.

Eulenburg's theory can, however, not be readily dismissed. Even if the purely mechanical theory of lateral curvature due to static influences be accepted, it is presumable that the faulty attitudes frequently assumed

by children in sitting and standing may be due to a lack of strength of certain groups of muscles, either inherited or acquired by accident; although it is not possible to demonstrate such impaired muscular strength of these muscles. In other words, muscular weakness may be regarded as a predisposing influence, if not an actual cause of the deformity.

With this in view it is alleged that the distortion is probably due to disturbed muscular conditions involving impaired muscular power on one side. The muscles primarily affected are probably not the external muscles moving the spinal column, but the internal group which pass from vertebra to vertebra, and act on the column in segments.

The second theory, that of abnormal growth, is advocated by Hueter and Engell, who believe that in some cases there is an abnormal growth of one side of the thorax, including the ribs and the vertebræ, similar to the unilateral atrophy or hypertrophy seen elsewhere; and that there is an abnormal ossification at the ends of the ribs in early childhood from which cause the thorax is twisted and developed asymmetrically.

Delpech and Bouvier think that faulty attitudes, instead of being the cause, are the result of lateral deviation, which are themselves due to asymmetrical development of the bodies of the vertebræ.

The position of the heart on the left side of the body has been explained to be an exciting cause for lateral curvature with the convexity toward the right. This, however, cannot be construed as true. The use of the right arm cannot be held wholly accountable, for in left-handed persons the left shoulder is frequently found higher than the right.

Many objections can be urged against this theory; but the most important is, that it does not correspond with clinical facts.

Lorinser has advanced a theory of subacute inflammatory changes in the structure of the bone, but there is little to be said in support of such a view. Lesser urged the view that the unequal action of the different halves of the diaphragm through unilateral paralysis of the phrenic nerves gave rise to the deformity.

The doctrine of faulty innervation as a cause of scoliosis has been advanced, but it has not yet received any acceptance.

The third theory is that of superincumbent weight. The majority of authorities favor this theory, urged by Roser and Volkmann, who consider the deformity as the result of the gradual mechanical force of the superincumbent weight falling upon the spinal column which is not held erect, and which is incapable of resisting the pressure which falls upon it.

The facts connected with lateral curvature may be briefly stated as follows:

The distortion occurs chiefly in childhood and develops fully in adolescence. In the earliest types there is an habitual distorted attitude which can be corrected by removing the superincumbent weight; in the later forms the distortion can be only slightly overcome by removing this

weight, and in the most severe forms no change can be effected in this way.

It remains, therefore, to investigate whether the anatomical changes found in cases of the severer type are such as can be caused by superincumbent weight. As has already been stated, these changes are chiefly a twist of the spinal column, and such alterations of the different vertebræ as would follow such a twist, provided the bony structures were unable to sustain such a downward pressure. To demonstrate that superincumbent weight could cause the twist the following experiments were tried:

Observation I.[1] The spinal column of a full-term infant was removed, leaving the skin, superimposed muscles, and ligaments intact, but removing the ribs. It was found that although the column was more flexible than in children, adolescents, or adults, rotation was not readily brought about by simply pressing the two ends toward each other, holding each end in the hand; the amount of lateral deviation, that is, curving sideways, without rotation of the bodies was not great, though much greater than in well-grown spinal columns. The most noticeable effect of pressing the upper part downward was to cause a bending with the concavity forward; bending with the concavity backward was possible only to a comparatively slight degree. Rotation was easily produced by twisting the spine.

Observation II. The body of a young female adult was hung by the head with the head fixed and the body free from the floor; the skin of the back having been dissected off, long pins were driven in the occiput and in the spinous processes of the different vertebræ; a thread with a weight was hung from the pin in the occiput, long enough to touch the floor, and a second thread with a piece of chalk attached was hung successively from the pins inserted in the different spines and from the sacrum. The pelvis was then twisted forcibly and the arc marked off on the floor by the piece of chalk, as suspended from the different pins, was measured from that point in the circle indicated by the plumb line, hung from the pin inserted in the immovable head.

The figures are as follows, measured from the line from the occiput:

Arc described by a line from				sacrum,	150°
"	"	"	"	axis,	60°
"	"	"	"	first dorsal,	83°
"	"	"	"	third dorsal,	100°
"	"	"	"	sixth dorsal,	118°
"	"	"	"	twelfth dorsal,	130°
"	"	"	"	third lumbar,	136°

While these figures are only approximate, as the amount of force used

[1] The writers are indebted to Professor Dwight and Drs. Mixter, Conant, Newell, and Burrell of the Harvard Medical School for their assistance in their experiments.

in the successive twistings was not measured and presumably not the same, yet they indicate that the amount of rotation possible is greatest in the dorsal region, leaving out of account the twisting possible in the atlo-axoid articulation. The three or four upper dorsal vertebræ moved together; the greatest rotation appeared to be in the third lower dorsal; lateral deviation (that is, without rotation) was possible only in the lower dorsal vertebræ. Pressure made on the floating ribs appeared to have little effect in twisting the vertebræ, but pressure on the thoracic ribs appeared in a measure to affect the line of the spinal column. Some play in the costo-vertebral articulation existed, but beyond that point pressure exerted on the ribs was transmitted to the column.

Volkmann[1] found that in life the greatest possible twist of the whole body, including that occurring in the hip-joints, was 144°, so that the figures here given are overstatements of the possible physiological limits of rotation. This is also somewhat greater than that indicated by the facets of the disarticulated vertebræ, which would show that if the joints were firm there would be absolutely no rotation in the lumbar region, little in the cervical, except in the atlo-axoid articulation, and not much in the dorsal region. A certain amount of laxity in the articulation allows more play than would be supposed by the structure of the bones. This was evident on forcibly twisting the cadaver.

The amount of forward and backward motion possible in an adult is much less than would be supposed. This is apparent on inspection, and has been accurately measured by Meyer.[2]

Observation III. The whole spinal column of an adult male, a dissecting-room subject, was taken, including a portion of the pelvis, and the base of the cranium. The larger muscles were removed, but the ligaments and smaller muscles were kept. The pelvis was firmly held in a vise and a box was secured on the cranium by passing a rod, firmly secured to the box down into the medullary canal of the cervical vertebræ; the box was then secured so that it would move up and down, but not laterally; weights were placed in the box.

It was found that the spinal column could bear a considerable weight without yielding to any noticeable extent. As the amount was increased a curvature with concavity forward was seen, which increased as the weight was increased up to eighty-four pounds. No rotation of the vertebræ was observed so long as the weight bore down directly, but rotation of the lower dorsal and lumbar region was seen when any lateral deviation was made in the cervical region; the amount of rotation or

[1] Virchow's Archiv, 1872.

[2] "Die Statik und Mechanik des menschlichen Knochengerüstes," p. 210; Virchow's Archiv, Bd. xxxv., p. 225; Ibid., Bd. xxxvi., 1866, p. 144; Ibid., xxxviii., p. 15.

deviation was, however, very small as compared with that possible in children.

None of these experiments approximately reproduced the conditions to be found in life, as the attachments of the ribs had been severed and the viscera removed. Furthermore, the spinal column in the adult is much less flexible than that of a child or adolescent, in whom lateral curvature is usually observed.

Observation IV. The body of an infant of a year was prepared in the following way: The thighs were amputated near the hip-joints and

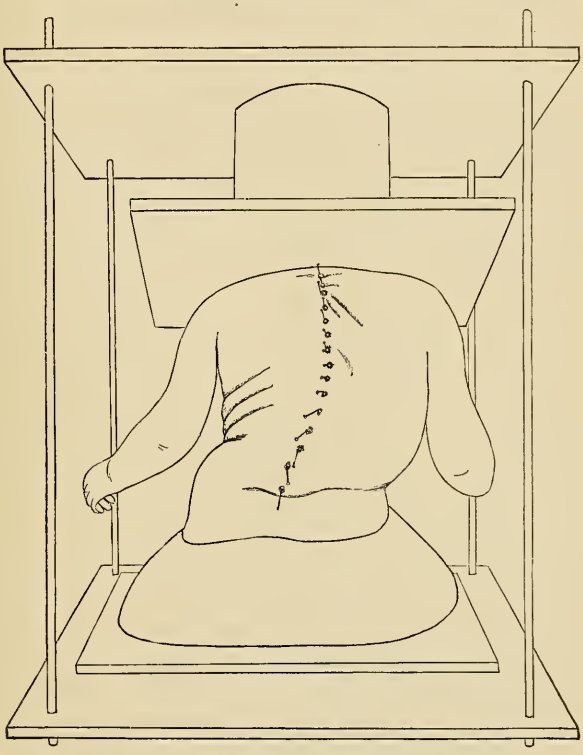

FIG. 101.—Experiment to Demonstrate Causation of Lateral Curvature.

the pelvis was fixed upon the remaining stumps and secured by means of nails on a board, long pins were passed laterally through the pelvis and secured to the board by means of hooks, and the whole pelvis was then embedded in plaster-of-Paris.

The board to which the body was secured was then placed on a stand with four upright rods attached at the four corners, to which rods a flat board was attached so that it would slide smoothly up and down. The child's trunk therefore was placed between two boards, one being fixed and the other pressing down upon the child's head. To keep the head in

place it was inserted in a tightly fitting tin cylinder which was fastened to the under surface of the board. Weight placed upon the upper board (sliding as it did freely upon the uprights) brought a downward pressure upon the child's head and shoulders. To make the latter more even, a wooden collar was placed around the neck resting on the shoulders. Long pins were then inserted in the spinous processes of the vertebræ so that rotation could be more readily noticed. To check the falling forward of the neck, a cord was placed around the neck and fastened at the side to the uprights, acting as a check, just as in life the longer muscles of the back would act in keeping the body erect.

Downward pressure upon the upper board caused the child's back to bend backward (convexity backward). When carried beyond a certain point the column would bend sideways with marked rotation, with the changes usually noticed in the ribs, flattening on the side of the concavity and projection on the side of the convexity. This projection was most marked in the middle and upper dorsal region, but the amount of greatest rotation appeared to be in the lower dorsal region. If the angle of downward pressure was changed, or if the pelvis was tipped so as to cause a curve in the spinal column, the effect of downward pressure was more marked.

Rotation of the vertebræ was, of course, readily produced by lateral pressure twisting the spine; and on removing all downward pressure, by placing the cadaver in a horizontal position rotation and curvature in the dorsal region was easily made by twisting the pelvis and holding the head fixed, or *vice versa*, the axis of the head and pelvis being kept the same.

Although a well-marked scoliosis was thus artificially produced, attended by the characteristic flattening of the ribs on the side of the concavity and projection on that of the convexity, yet a more careful examination appeared to show that although this was the result of downward pressure, it was downward pressure not exerted in a perfectly vertical direction; for although the force was applied properly, yet it was not possible to prevent some play in the cervical region, from which it resulted that the force fell obliquely upon the under portion of the spinal column, causing curvature and necessarily rotation.

The accompanying illustration (drawn from a photograph) indicates the lateral curvature produced in the experiment.

The photograph of a case of lateral curvature in a grown child shows the similarity of the shape of the back in true lateral curvature to that of the experiment.

If it were practicable to apply a force directly downward and transmit it through the cervical and upper dorsal region without deviation, the effect upon the lower dorsal region would be to cause an antero-posterior curvature.

The lateral curvature therefore results from downward pressure, but

downward pressure applied obliquely upon some portion of the spinal column. Rotation follows from the anatomical structure of the interlocked vertebræ, it being possible for them to rotate slightly, while the amount of tipping sideways (without twisting) which the articular facets permit is much less.

Rotation takes place with the vertebral bodies directed toward the convexity and the spine to the concavity for the reason that the former, being larger, are unable to be crowded into the smaller space of the concavity, and are pushed in the direction where there is more space. The fact also has been pointed out by Judson, that the bodies are free while the spines are held by muscles which may give the former more freedom in movement.

From the above facts the following generalizations may be made:

The effect of the weight of the thorax, head, and shoulders would be, if applied in a vertical direction, to bend the spinal column forward and backward, but in flexible spines the superincumbent weight rarely falls directly, and curvature follows. This is at first a physiological process, but it subsequently becomes, by the alteration in the shapes of the bones under altered pressure, a pathological change.

The extent of the curvature and the situation of the curve will be determined by the attitude habitually taken by the individual, and perhaps also by a difference in the resisting power in different parts of the column.

The injurious effect of superincumbent weight in curving the spine is increased by the obliquity of the pelvis, or the inclination of the shoulders so frequently taken by persons of weak muscular systems in sitting sideways and leaning. The curve is usually in the dorsal region, with the right shoulder raised, as the majority of people are right-handed.

The distortion is one of growing years, and is more common in girls than boys, for two reasons, namely, that at the age when lateral curvature is usually seen first girls grow more rapidly than boys, and their muscular system is less well developed from the customary life habits of girls in society. The effect of superincumbent weight upon a yielding spine in adult life, after the vertebræ have ceased to grow, is to cause an increase in the antero-posterior curve of the back.

The lack of normal resistance of the bony structures of the spinal column, in part or in whole, may be supposed to exist in certain individuals without the supposition of any pathological change of sufficient gravity to be classed as rickets. During the age of growth, complete ossification of the different vertebræ has not been attained. It is well known in certain cases that in rapidly growing persons the ossification of the spine does not make equal progress with the ossification elsewhere.

Alexander Shaw mentions two preparations of the spine in the

Museum of the Middlesex Hospital, where such a condition of things existed.[1]

Analogous to this condition is that found in the knock-knee developing about the time of puberty. This view would be supported by Vogt, who calls attention to the fact that the development of ordinary lateral curvature comes at periods of the physiological increase of the process of ossification of the whole skeleton. Vogt describes three periods of increase of growth: 1st, includes the first two years; 2d, the beginning of the second dentition in the seventh year to the approach of the time of puberty; 3d, the period of puberty. Fisher writes that attention should be especially directed to the fact that mere constant bending of the spine to one side will not induce a structural change; that there must exist also within the column itself some contributory defect, without which lateral curvature will not become developed.

Adams and Fisher believe that this contributory defect is in the structural relaxation or weakness of the ligaments, rather than in a lack of resistance of the bones. Fisher, however, himself compares the condition to that seen in knock-knee, which is now generally regarded to be due to an osseous rather than to a ligamentous defect.

The constitutional influence in the development of lateral curvature is little understood. Drachmann found that only a small portion of the anæmic and scrofulous children in the 28,000 scholars examined were scoliotic. An hereditary predisposition to spinal curvature frequently coexisting with a consumptive tendency is mentioned by Adams as occurring in girls from seven to twelve years of age or later; and in those cases the curvature tends to increase rapidly and terminate in a conspicuous deformity; but lateral curvature of the spine according to Adams rarely coexists with consumption. Eulenburg found that 25 per cent of scoliotic patients showed some hereditary tendency toward the affection. Vogt found it in one-half of his cases. While Rupprecht[2] considers ordinary lateral curvature as rhachitic, Lorenz thinks that weakly children have *ipso facto* a disposition to lateral curvature; but he is unwilling to say that in cases in which it occurs the children are always rhachitic; for the lack of resistance of a rapidly growing bone may be sufficient, under certain static conditions, to develop the lateral distortion.

Sigfried Levy[3] thinks that there are two distinct etiological factors in the production of habitual scoliosis: one, "an anomaly of nutrition," a purely organic matter; secondly, certain mechanical causes—faulty positions of standing and sitting. Neither one of the factors can cause it alone; both must be present at the same time. In support of this

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[1] Holmes' "System of Surgery," vol. iii., American edition.

[2] *Vide* Centralbl. f. orthop. Chir., 1886, 2.

[3] Also Busch: Berl. klin. Wochenschrift, 1880, p. 106, vol. i.

view, he speaks of a case which he saw, in which a girl of three years had a resection of the knee, and grew up with one leg 9 cm. shorter than the other. The pelvis was always tilted, but there was no suspicion of scoliosis until she was twelve years old, when she began to have headache, pain in the side, malaise, etc., and in spite of all precautions a typical lateral curvature rapidly developed. He

FIG. 102.

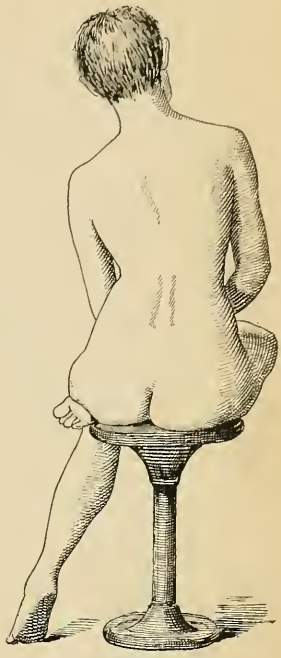

FIG. 104.

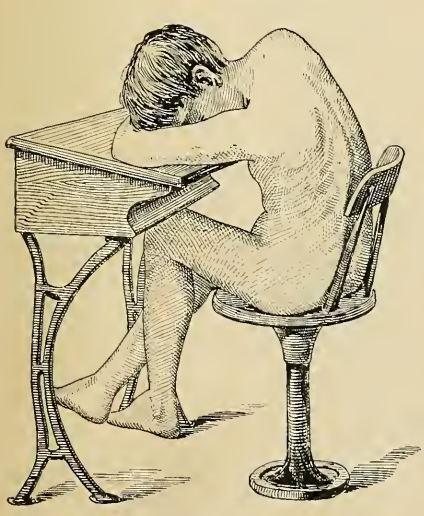

FIG. 103.

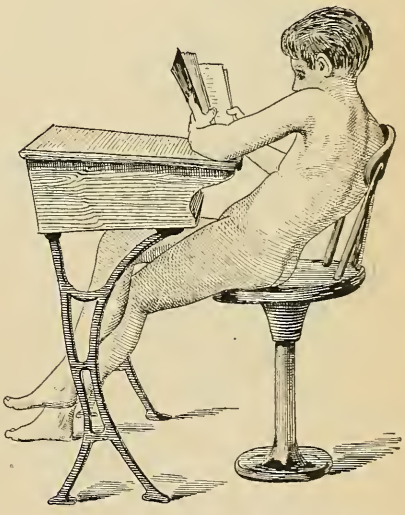

FIG. 105.

FIGS. 102–105.—Incorrect Attitudes of Sitting in School Children. (Scudder.)

has seen three other such cases; and in over a hundred cases of habitual scoliosis which he has observed, in every case symptoms of general disturbance (as in the case related above) accompanied the development of the deformity.

As has been shown by Redard, the position in which children in arms are carried, if persisted in for many hours, may develop abnormality in the shape of certain of the vertebræ. This remains unnoticed in early youth, but as the weight of the trunk increases, gives to a weak-muscled child greater ease in a one-sided position, and the position becomes habitual and, under the proper conditions, scoliosis follows.

Symmetrical development on both sides in the shape of the vertebral bodies is not the rule, as was shown by Dr. R. Tunstall Taylor in an examination of a number of normal adult spines in the Warren Museum, at the Harvard Medical School.

As is well stated by Fisher, the causes of lateral curvature are the predisposing and the proximate.

1. Predisposing causes, which are constitutional, such as debility, rickets, or a condition of lack of resistance in certain of the vertebræ.

2. Proximate causes (essentially local), which disturb the equilibrium. These are vicious positions, sitting positions, faulty attitudes, empyema, or any long-continued irregular distribution of weight. To this can be added an inequality in the length of the limbs, which is an occasional predisposing cause.

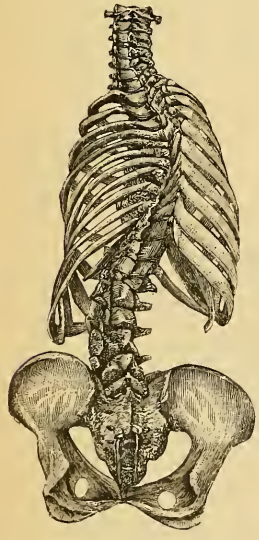

FIG. 106.—Distortion of Ribs in Lateral Curvature. (Schreiber.)

PATHOLOGY.

The pathological changes in true lateral curvature are not those resulting from any destructive disease of the vertebræ, but simply the alterations of bone altered under pressure in an abnormal direction.

The changes are chiefly to be noticed in the spinal column, viz., the bodies of the vertebræ, the articulating processes, and the spines; but in severe cases all the bones of the trunk may be altered and also the pelvis. The muscles and ligaments are altered in their tonicity and length, and internal organs may be displaced.

The changes seen necessarily vary according to the stage of the affection and the degree to which the deformity has developed, and consist chiefly of a curvature and torsion.

In the flexible stage of scoliosis no anatomical change will be found in

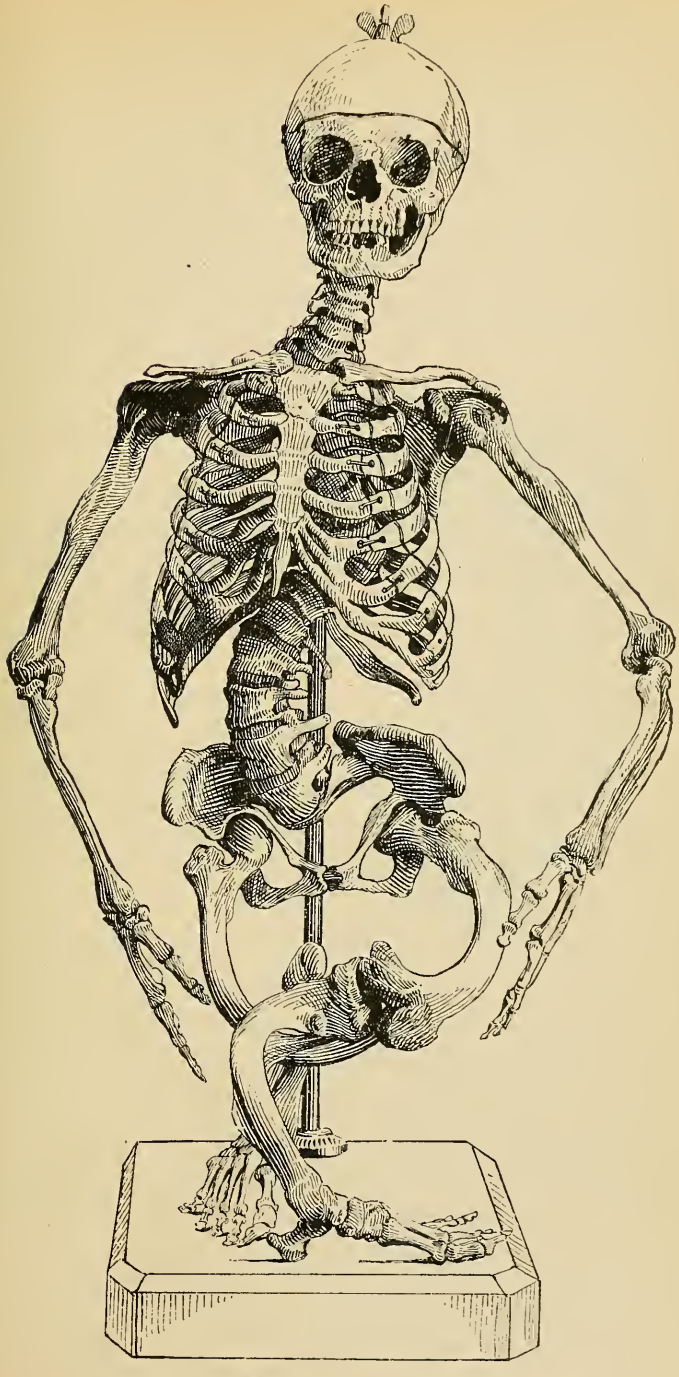

FIG. 107.—Rhachitic Lateral Curvature of Spine, from Specimen in the Warren Museum.

the bones, ligaments, or muscles; but in the stage of fixed curves, and in the latest phases of the affection, marked distortion of the vertebral bodies is to be observed.

Wherever a side curve of the spine has taken place the bodies are crowded together on the concave and separated on the convex side of the curve. Growing bone adapts itself to altered pressure, and in time the vertebral bodies will be found thicker on one side than the other, and changes in the shape of the articulating and transverse processes will also take place. Distortion in the shape of the bodies also occurs from osseous growth to meet abnormal pressure, as has been shown by Wolff. As has already been stated, a twist takes place in the spinal column, and

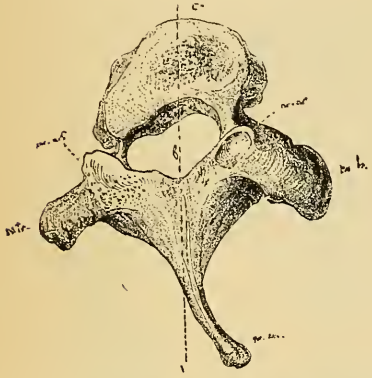

FIG. 108.—Individual Vertebræ Altered in Lateral Curvature. (Schreiber.)

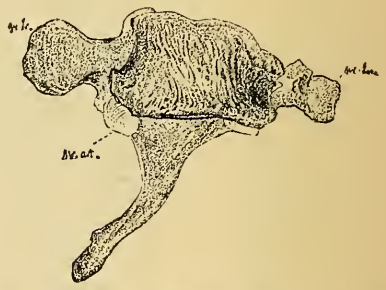

FIG. 109.—Individual Vertebræ Altered in Lateral Curvature. (Schreiber.)

consequently the transverse processes are out of the normal plane; the ribs follow the transverse processes, and a characteristic projection on one side and flattening on the other occur.

If the column is curved laterally in two or three directions, rotation necessarily takes place in different parts of it in opposite directions. The projection of the ribs is naturally more noticeable than the projection of the transverse processes without ribs; but in the lumbar region the muscles are thrown forward, or recede, giving a characteristic alteration in the contour of the trunk.

The intervertebral cartilages necessarily twist with the vertebræ and are compressed on one side more than on the other in cases of marked curves; but in severe cases they will be found on measurement thicker on the side of convexity than of concavity, so that instead of being flat, they are wedge-shaped, from side to side.

In some cases, as has been shown by Adams and others, the tips of the spines in severely rotated columns may be on a straight line, while the bodies are badly distorted, the axis of rotation being near the spinous processes.

For an understanding of this torsion, it is well to bear in mind that the structure of the spinal column is such that a bending to the side without any twisting of the column is possible only to a limited extent. The purely sidewise motion of the column, the only motion possible in fish, is fully developed in reptiles and in some animals, but is limited in man. In old people it may be almost wanting, though in fœtal life and in infants it is much more free.

A detailed anatomical description of the structure of the vertebræ is hardly necessary for an understanding of the phenomenon of torsion.

The individual vertebræ rotate on each other to a limited extent; the amount of possible rotation varying according to age and the condition of the spine. The various parts of the spinal column permit a different amount of rotation; the upper cervical region permitting the most, and the lumbar region the least.

When the demands of the individual require more

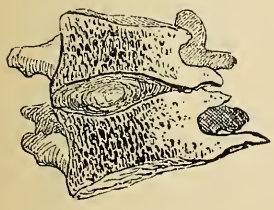

FIG. 110.—Change in Shape of Bodies of Vertebræ. (Schreiber.)

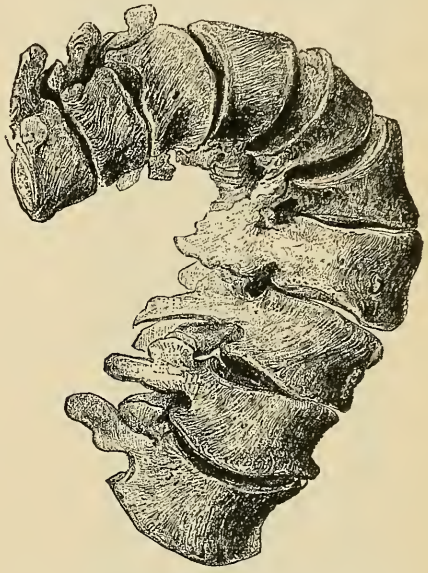

FIG. 111.—Torsion in Lateral Curvature. (Schreiber.)

motion to the side than would be possible by the purely sidewise bending of the column, this can be gained by a torsion of the column so that the freer antero-posterior movement of it may aid the limited side motion.

Some discussion has taken place as to whether the torsion is primary to the curve or secondary. Schmidt [1] is of the opinion that the torsion is primary, as there is always a curvature if torsion exists, but slight curvature may take place without torsion. The question cannot be considered one of great importance.

Dr. Judson's excellent experiment to demonstrate the phenomenon of rotation is well known, and can be understood by a glance at the accompanying illustrations. A flexible rod is passed through the disarticulated

[1] Centralblatt f. Chir., November 11th, 1882.

vertebræ of a spinal column, placed in their normal order, one above another, and kept in relative position by means of elastic straps, secured to uprights. Increase of downward pressure demonstrates rotation and lateral curvature.

There is, therefore, necessarily a torsion of the spinal column whenever it is bent toward the side to any considerable extent; and when a curved condition of the spine becomes habitual or constant the changed pressure in the spinal column produces in time alterations in the shape of the vertebral bodies, and in the articulating surface.

Lorenz has clearly shown that not only do

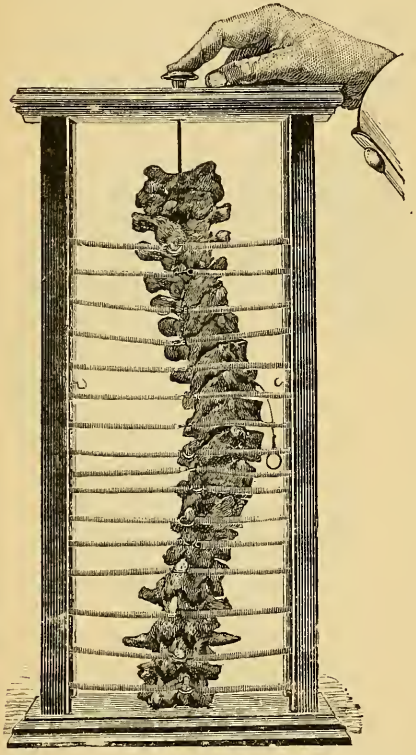

Fig. 112.

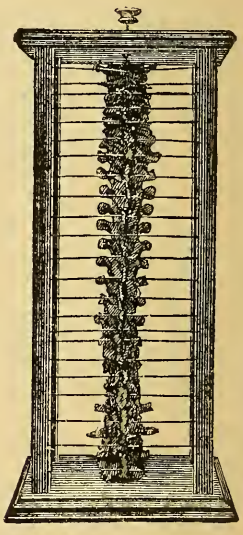

Fig. 113.

Figs. 112, 113.—Judson's Apparatus to Demonstrate Rotation.

the bodies of the vertebræ give evidence of torsion around the axis of the spinal column, but there is, in advanced cases, evidence of torsion of the bodies themselves in oblique and spiral longitudinal striations on the bodies in the place of the usual vertical marking. Besides the rotation, as has been stated, the bodies grow in the direction of the least pressure; consequently the bodies lose their normal symmetrical shape; the spinal canal becomes irregularly oval in shape, and the transverse and articular processes are altered according to the position of the vertebræ; those on the crowded side being broader and lower than on the

convex side. The shape of the vertebræ is indicated in the accompanying pictures (Figs. 110 and 111), but it must be borne in mind that the vertebræ vary necessarily according to their relative position in the curve and to the direction in which they receive the superincumbent pressure.

The alterations of the bones in the vertebral column are not to be studied in the individual vertebræ. The whole column is twisted and all the bones are necessarily altered according to the abnormal positions, as a result of those atrophic changes in bone which always result from abnormal pressure or weight bearing.

The ribs are not only rotated, but altered in shape, as is seen in the accompanying picture (Fig. 114). They are also altered in the line of their obliquity, being lowered on the side of the concavity of the curve.

The contour of the thorax is changed from the altered shape of the ribs; the clavicles remain unchanged; but the tip of the sternum may be deflected from the median line. The ribs project backward at the angle on the side of the convexity of the curve and forward in the line of the concavity.

A cross section of the thorax shows an alteration of the diagonal axes of the chest, which should normally be equal, but in the ordinary dorsal right convex curve the diagonal axis from the left front side to the right back side of the thorax is longer than the other side.

The different halves of the thorax, on cross section, should be symmetrical normally, but in lateral curvature the portion on the convex side

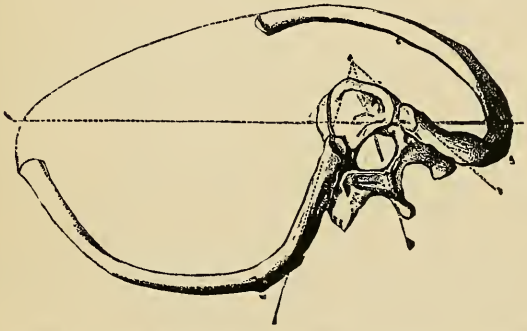

Fig. 114.—Distortion of Ribs and Thorax in Lateral Curvature. (After Lorenz.)

is smaller than that on the concave side, owing to the flattening of the ribs. The vertebral bodies are also crowded into this half of the thorax, so that there is less room for expansion of the lung on that side than on the other side.

In the severest cases of distortion, the lower ribs on one side may rest upon the crest of the ilium or even sink into the pelvic cavity.

The muscles of the spinal column in an early case of lateral curvature are unaffected, except in cases of a purely paralytic nature.

Adams found in dissections of advanced cases that the muscles on both sides of the spine "were much wasted, reduced to very thin layers, pale in color, and in more or less advanced stages of fatty degeneration, which probably commences in the muscles in the concavity of the curve, those on the convexity wasting at a much later period." (The muscles in the concavity of the curve are found neither prominent nor rigid.)

In advanced cases of lateral curvature, the ligaments on the concave side of the spinal column are shortened and those on the convex side are elongated. This is the result of adaptive shortening of them, and is not found in the early stages of the affection.

Distortion of the Pelvis in Cases of Lateral Curvature of the Spine.—The pelvis is not necessarily distorted in lateral curvature of the spine, but the bones of the pelvis may, if not sufficiently unyielding in their structure, become altered by abnormal pressure or strain. The pelvis may assume the position of obliquity from a prominence of one hip due to the uncovering of the crest of the ilium by the over-projecting ribs, but true obliquity is exceptional.

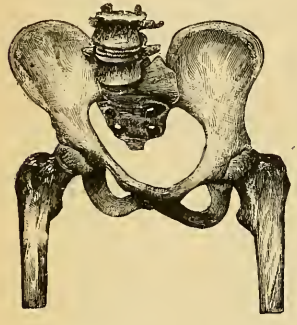

FIG. 115.—Distorted Pelvis in Lateral Curvature.

When there is irregularity in the length of the legs, obliquity of the pelvis necessarily exists. The prominence and rigidity of the spinal muscles in the lumbar region frequently seen on the convexity of the sharp lumbar curve often convey to the touch a doubtful sense of fluctuation, and have frequently led to the suspicion of an abscess. The spinal cord is not affected by lateral curvature.

The spinal nerves in consequence of the large size of the foramina are not liable to suffer compression except in cases of great distortion.

Influence of Lateral Curvature in Causing Displacement of Abdominal Viscera.—The abdominal viscera are less likely to be displaced, even in severe cases, than the thoracic organs, though the liver may be out of place and altered in form, according to the direction and extent of the spinal distortion. The spleen may suffer some compression, and the aorta is necessarily displaced; Adams reports a case in which at a post-mortem examination he was barely able to pass the hand between the bodies of the vertebræ and the ribs. The lung on the convexity of the curve is, therefore, much more compressed and flattened, and the thoracic cavity on the concavity of the curve is always found to be much larger than would be expected. The lung on the concavity of the curve may be altered in form, but is not diminished in bulk as on the side of convexity. The heart is generally found displaced toward the concavity of the curve in severe cases.

Diagnosis.

A diagnosis of lateral curvature, in a severe case, is so simple that an inspection of the patient is all that is required.

In the less-marked cases, however, the recognition of the true nature of the deformity is not so easy, and a careful examination is necessary, not only for the exclusion of other affections of the spine, but also for an insight into the stage and progress of the lateral curvature, and the amount of rotation and bony change in the spinal column.

The method of examination of a case of lateral curvature is as follows:

The patient's back should be bared to the level of the trochanters, and the arms should be allowed to hang free. The most natural attitude in standing should be noted and also the position of the patient in an attempt to stand in as straight a position as is possible; the tips of the spinous processes are to be marked with a crayon and also the ends of the scapulæ. To determine the central line a string, to which a slight weight is attached, is hung from the seventh cervical vertebra (to which it can be fixed by a piece of adhesive plaster), the string being long enough to hang to the cleft of the buttock. The distance of the tips of the scapulæ (the arms being crossed in front of the chest) from this central line should be measured, and also the distances from this line to the points of greatest curvature of the line of the spinous process. These points being noted, the slope of the shoulders, the outlines of the sides of the trunk, and the contour of the back, as well as any lack of symmetry or unilateral fulness, should be carefully recorded, both when the patient is standing and in the stooping position, with the back well arched. If a deviation of the line of the spinous processes is observed, a lack of symmetry of outline, or a unilateral projection of the ribs or scapulæ, in the erect position, the patient should be suspended by means of a head sling and also made to lie in a recumbent position upon the face. A marked alteration of the curvature, contour, or outlines following removal of the superincumbent weight is of particular importance.

The inspection of the arched back, stooping from a sitting position, is important; any rotation of the fixed ribs due to osseous change is easily detected in the lack of symmetry and projection of one side more than the other.

The flexibility of the spine should be tested by causing the patient to stand first with one foot, and then the other upon a series of blocks half an inch in thickness, and testing what height can be placed under the patient's foot without preventing her from standing upon both legs with the limbs straight and without flexion at the knee; this tests the lateral flexibility in the lower part of the spinal column. In testing the flexibility higher up, the patient should be seated on a stool, and one hand

of an assistant be placed upon her side, above the crest of the ilium, while the other hand should be placed upon the crest of the ilium. The patient should then be directed to bend sideways toward the side of the higher hand, and the amount of this motion, without tilting of the pelvis, is to be noted.

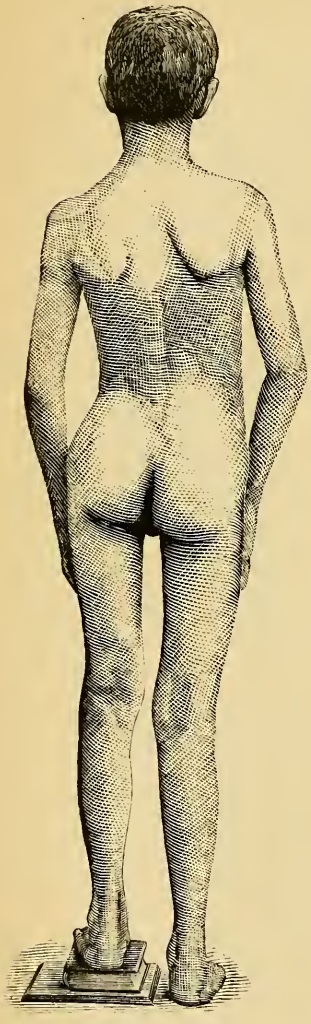

Fig. 116.—Lumbar Flexibility of the Spine.

The lateral flexibility can be often readily seen by directing the patient to bend to one side, keeping the legs straight and avoiding twisting the pelvis.

The amount of possible rotation of the spine may also be of importance; in which case the patient should sit upon a revolving stool with the shoulders held firmly by an assistant when the amount of possible revolution of the stool in one direction or another, without turning the shoulders, can be approximately estimated.

It is not always necessary to examine the front of the patient's trunk. When this is done, the projection of the ribs in front, and the difference in the prominence or flatness of the two breasts, the deviation of the tip of the sternum and of the umbilicus from the median line are of importance, as indicating the amount of structural change which has taken place.

The strength of the muscles of the patient's back may be tested by means of a dynamometer, or spring balance, and the height and weight should be recorded and compared with the normal standard for the age as given.

A diagnosis of lateral curvature in the early stage is to be made by observing in any case an habitual lack of symmetry in the outline of the sides of the trunk, the slope of the shoulders, or contour of the back, in the unnatural projection of one shoulder blade or a portion of the trunk on one side or of one hip; and on a constant deviation of the line of the spinous processes from the vertical line.

An accidental assumption of any position with the prominence of

these symptoms does not necessarily constitute lateral curvature; but the constant habitual assumption of such a position, when the patient stands in the attitude of ease and greatest comfort, must be regarded as a lateral curvature either of a flexible or fixed type.

Adams and Fisher claim that a distinction should be made between deviations and curvatures of the spinal column, and state that much of the confusion regarding causation and the results of treatment is from a lack of this important distinction. This distinction, however, is not always a practical one, as in the early stage of lateral curvature before fixation has occurred permanent rotation is not always recognizable.

The amount of fixed rotation is best indicated by the amount of unilateral projection of the ribs at the level of the shoulder or in the hollow of the back when the patient bends forward or is recumbent.

The amount of osseous and ligamentous change is indicated by the amount of stiffness or the slight change in the curves and asymmetrical symptoms as the patient alters the position standing, lying, or in suspension.

In this way it is possible to determine the amount of progress the distortion has made, and the stage of the affection.

A notable error in the diagnosis of lateral curvature is recorded by Mr. Adams in the practice of surgeons of the last generation, which seems hardly possible at the present time. The relaxed muscles in the lumbar region in a case of severe lateral curvature were mistaken for a deep abscess, and operative measures were advised by several surgeons of prominence. The subsequent result proved the swelling to be purely the deep muscular tissue in the loin made prominent by the rotated transverse vertebræ on the convexity of a lumbar curve.

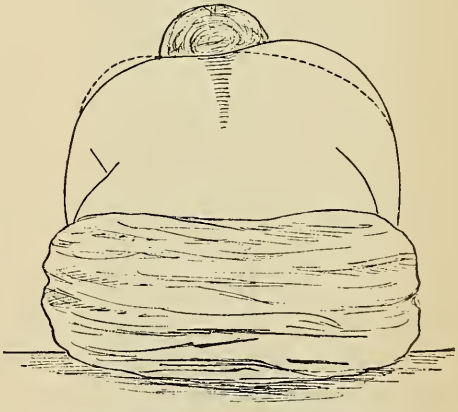

Fig. 117.—Projection of Side of Thorax in Lateral Curvature, Seen when Back is Bent.

The writers can record a large dorsal lateral curve with severe rotation of the ribs which was mistaken by a physician (a skilled specialist in diseases of the chest) for an obscure form of pleural effusion.

Lateral curvature is not infrequently confounded with caries of the spine through simple ignorance of the nature of either affection, both being classed as chronic spinal affections. In pronounced lateral curvature,

the lateral twist and the rotation are essentially different from the curve of Pott's disease, which is chiefly an antero-posterior curve. In the former, rotation is an unmistakable symptom; in the latter, it is absent or slight. In the slighter cases of lateral curvature the spine is flexible, and the lateral curve diminishes or disappears on recumbency; and there is never a sharp angular projection. In Pott's disease the spine is not flexible but stiff, the curve is angular, and it does not disappear on recumbency.

Methods of Recording Lateral Curvature.

For clinical purposes a careful record of lateral curvature is necessary.

In recording lateral curvature it is necessary to note the flexibility of the spine, the curve, and the amount of twist or rotation. Nothing is better than photographs carefully taken. For this purpose the spinous processes should be marked, and a line drawn from the anterior superior spine to the cleft of the buttocks, which may be termed the median line of the body. The patient if standing should be placed squarely before a camera and photographed with such arrangement of light as to prevent strong shadows. A photograph should also be taken with the patient recumbent upon a hard surface with the anterior superior spines and the shoulders in contact with the surface upon which the patient lies, thus securing a fixed position; if the head is dropped over the edge of the table, the arms are extended at right angles, and the camera is suitably placed, a photograph can be taken in a profile of the cross-section of the back, thus showing the rotation. The rotation can also be photographed if the standing patient stoops and the camera is focussed on the portion of the back showing the greatest rotation of the spine. If the camera is placed directly above the patient lying flat upon the face and the picture compared with that of the standing position, the amount of flexibility of

Fig. 118.—Thread Frame for Recording Deviations of the Spine. (Children's Hospital Report.)

the spine and of the amount of fixed curve can be estimated by the change in the marked lines.

A more ready but less reliable means of record can be furnished by the following measurements made and recorded from the bony points and lines previously marked upon the back: First, the distances between the middle line and the point of maximum curve of the line of the spines in the upper and lower curve if both exist; second, the distance from the spine of the seventh cervical vertebra to the point where the median line crosses the line of curve.

These measurements, taken of the patient lying and standing and compared, indicate by their difference the amount of fixedness of the curve, and as they are taken from anatomical landmarks easily found are of sufficient accuracy for ordinary practical purposes.

An accurate record of rotation is more easily made if the patient is recumbent; the muscles are relaxed and there is less danger of error from muscular effort of the patient. A cross tracing of the back taken at a recorded point and at a measured distance from the vertebra prominens is of reasonable accuracy if carefully made.

Prognosis.

No accurate data are in existence which enable us to form a definite prognosis. Two errors in prognosis are common. First, that the disease is of the most serious nature; second, that it is a trivial affection and will be readily outgrown by the patient. The fact is, that in the larger number of these cases the affection is a self-limited one, occasioning slight deformity, which persists through life, causing no trouble and recognized only by the dressmaker or by some near relative.

In other cases, however, the disease becomes decidedly worse as the deformity increases, and a pitiable distortion follows, causing a great deal of neuralgic pain and a marked deformity.

It is impossible to state positively in what instances an increase of the curve will take place and when they can be relied upon to remain stationary. It may, however, be said that when the physical condition during the growing period remains constantly below the proper standard, and when the patient's growth is rapid, an increase of curve is to be apprehended. The decrease or diminution of lateral curvature from simple growth without treatment is not to be expected.

Sometimes the disease may remain to a slight extent during girlhood and early womanhood, developing an increase at a period past middle life. Such cases are rare, and are dependent upon a loss of general health.

In determining the prognosis in any given case the following facts must be ascertained and borne in mind:

First, the probable rate of growth. This can be ascertained by the patient's height, the hereditary tendency toward height as ascertained by the height of the parents and the parents' families. The general opinion is that completion of growth exerts a powerful influence in arresting progress of the curvature. In a girl of health at the age of twenty, with only a slight degree of curvature, this may remain without increase for life, or for a while; but there remains a liability to increase, and Adams notes a case in which a patient, with a slight curvature up to the age of forty, developed a very severe curvature at sixty owing to failure of general health.

The physician should bear in mind certain facts as to the rate of growth of children. Malling-Hansen,[1] as director of the Royal Deaf and Dumb Institution, has examined one hundred and thirty children, weighing them at different times. The boys were weighed at 6 A.M. and 9 P.M. The girls were weighed once a day, at 2 P.M. He found that a child might weigh from one to two pounds heavier at night than in the morning, and be more than one pound and a half lighter in the morning than it was in the evening before exercise. Bathing did not influence the weight. There was always an increase after a full meal. He found that there were three periods in which the weight varied: first, a period of decrease from the middle of May in each year to the middle of July; a period of increase of great importance from the middle of July to the middle of November; and then a period in which the child's weight increased slightly, but often remained stationary, and might even diminish, from the middle of November to the middle of May. Temperature had an effect upon increase and decrease, increase of temperature being accompanied by increase in weight, and *vice versa*. Boys consumed one-fifth more than girls.

In general it may be said that if a patient has gained full height and development in figure, any increase in growth is not often to be expected, and that an increase in curve is not probable after the osseous system has become thoroughly formed.

The conclusions of Pravaz are well expressed, who considers that "the patient's general condition is of great importance in the prognosis of lateral curvature. Chlorosis and imperfect nutrition are unfavorable to the re-establishment of the figure. In general, recovery of the figure is more to be expected in younger than in older patients, but the writer wishes to warn against the prevalent idea that patients will grow out of a curve of the spine. The prognosis in curvature following phthisis is unfavorable, and distortions due to disturbances of muscular action are often very difficult to treat, and rickety distortions are more unfavorable for treatment than those due to a loss of flexibility of the spine in chil-

[1] Brit. Med. Journ., September 20th, 1884.

dren at the time of the second dentition or puberty. Curvatures submitted to treatment at an early stage, even when quite pronounced, may become corrected provided the patient's general condition is good, the prognosis depending in a large measure upon the amount of rotation of the vertebræ present, rather than on the amount of the curve. Curvatures in the lumbar region are less favorable than those in the dorsal region, and curvatures with a long radius are more readily straightened than those with a short."

The normal height and weight of male and female are here given for the sake of reference.

TABLE OF HEIGHT AND WEIGHT OF THE HUMAN BODY.

Male.

Age.	Height in Feet and Inches.	Weight.
At birth	1 ft. 7 in. (0.496 m.)	7 lbs. (3.20 kgm.)
1 year	2 " 3 " (0.696 ")	22 " (10.00 ")
2 years	2 " 8 " (0.797 ")	26 " (12.00 ")
3 "	2 " 9 " (0.860 ")	29 " (13.21 ")
4 "	3 " (0.932 ")	33 " (15.07 ")
5 "	3 " 3 " (0.990 ")	36 " (16.70 ")
6 "	3 " 5 " (1.046 ")	39 " (18.04 ")
7 "	3 " 8 " (1.112 ")	44 " (20.16 ")
8 "	3 " 9 " (1.170 ")	49 " (22.26 ")
9 "	4 " (1.227 ")	53 " (24.09 ")
10 "	4 " 2 " (1.282 ")	57 " (26.12 ")
12 "	4 " 6 " (1.359 ")	68 " (31.00 ")
14 "	4 " 10 " (1.487 ")	89 " (40.50 ")
16 "	5 " 3 " (1.610 ")	117 " (53.39 ")
18 "	5 " 6 " (1.700 ")	135 " (61.26 ")
20 "	5 " 8 " (1.711 ")	143 " (65.00 ")
25 "	5 " 9 " (1.722 ")	150 " (68.29 ")
30 "	5 " 9 " (1.722 ")	152 " (68.90 ")
40 "	5 " 8 " (1.713 ")	151 " (68.63 ")

Female.

Age.	Height in Feet and Inches.	Weight.
At birth	1 ft. 6 in. (0.483 m.)	6 lbs. (2.91 kgm.)
1 year	2 " 3 " (0.690 ")	20 " (9.30 ")
2 years	2 " 6 " (0.780 ")	25 " (11.40 ")
3 "	2 " 9 " (0.850 ")	27 " (12.45 ")
4 "	3 " (0.910 ")	31 " (14.18 ")
5 "	3 " 2 " (0.974 ")	34 " (15.50 ")
6 "	3 " 4 " (1.032 ")	37 " (16.74 ")
7 "	3 " 7 " (1.096 ")	40 " (18.45 ")
8 "	3 " 9 " (1.139 ")	43 " (19.82 ")
9 "	3 " 11 " (1.200 ")	50 " (22.44 ")
10 "	4 " 1 " (1.248 ")	53 " (24.24 ")
12 "	4 " 4 " (1.327 ")	67 " (30.54 ")
14 "	4 " 9 " (1.447 ")	84 " (38.10 ")
16 "	4 " 11 " (1.500 ")	98 " (44.44 ")
18 "	5 " 1 " (1.562 ")	117 " (53.10 ")
20 "	5 " 2 " (1.570 ")	120 " (54.46 ")
25 "	5 " 2 " (1.577 ")	121 " (55.08 ")
30 "	5 " 2 " (1.579 ")	121 " (55.14 ")
40 "	5 " 1 " (1.555 ")	129 " (58.45 ")

The prognosis is not good, so far as improvement of the curve is considered, in paralytic and rhachitic cases.

The lateral curvature seen in early Pott's disease is easily corrected by the proper treatment for caries of the spine. The deformity which comes on in the later stages and is dependent on osseous change is irremediable.

Preventive Measures.

As faulty attitudes exert an important influence in causing lateral curvatures, the avoidance of these is of importance in preventing curves. The attitude assumed in sitting is necessarily of great importance.

Schenk[1] has studied the attitude in writing assumed by 200 school children. In 160 the trunk was found inclined with a convexity of a lower dorsal curve. In 34 the trunk inclined toward the right, but the body twisted toward the left. In only 6 was there no twist of the body. In only 38 was the transverse axis of the body parallel with the desk, and in the others the pelvis was twisted obliquely to the right.

Scudder[2] has demonstrated the injurious effects of imperfect school seating in the Boston schools.

The writers have taken the opportunity to examine the attitude assumed in writing by sixty-seven healthy adult males, while writing in a three-hour written examination. At the end of two hours the attitudes were observed. In all the paper was inclined slightly, so that the written line formed an angle with the cross axis of the thorax. This angle varied from ten degrees to a right angle. The inclination of the paper was always such that the right upper corner was in front of the left. In a large majority of the writers the left side of the hip was in front of the right, the left shoulder in front of the right, but the left ear was usually slightly lower than the right and somewhat behind it. In all cases, therefore, there was a slight rotation of the spinal column. The trunk in three-fourths of the writers was inclined to the left, in about one-quarter to the right, and in the remainder it was held erect.

It may be fairly assumed that, if a twist of the spinal column is invariable in writing in strong men, faulty attitudes will be equally common in weakly children.

The proper attitude during writing is with the transverse axis of the trunk parallel with the edge of the writing table. The forearms should rest at least two-thirds of their length upon the table. The trunk should be held erect, the legs should be straight before the trunk, and the feet should rest upon a sloping cricket which rests and steadies the legs.

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[1] "Zur Aetiologie der Scoliosis," Berlin, 1885.

[2] Report Boston School Committee, 1890.

The proper attitude in writing in schools is favored by teaching the perpendicular in place of slanting writing.

Seats.—Chairs used by children frequently do not properly support the back muscles, which may be unduly stretched and thereby weakened. Children often assume faulty attitudes simply for the reason that proper support is not furnished the lower part of the back.

A fruitful source of faulty attitudes in sitting is furnished by chairs, which, not fitting the child or supporting the back properly, induce the

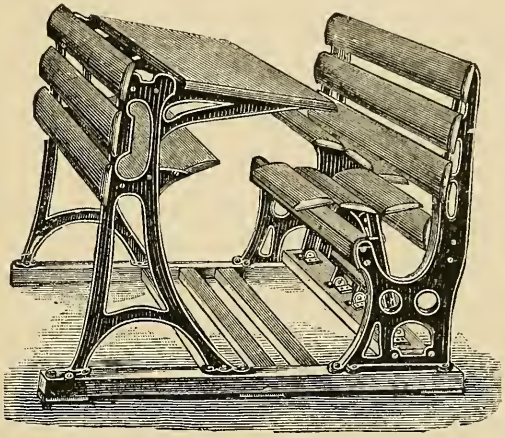

FIG. 119.—School Bench and Seat with Support for Hollow of Back. (From Schreiber, after Lickroth.)

patient to sit sideways, the trunk being supported on one tuberosity of the ischium. The seat of the chair in which the child is to sit for any length of time should not be deeper than the length of the thighs or higher than the length of the legs; its back should not be above the shoulders and should be arched so as to fit in the hollow of the back; or if this is not practicable, hard cushions or false chair backs made of leather stiffened with steel should be placed in the back of the chair so fitted as to act as a proper support.

For children with weak backs it is advisable that the lower part of the back should be well supported. If this is not done, the large muscles of the back will be unduly strained, as they are inserted into the broad fascia, which is attached to the sacrum and iliac bones, and faulty attitudes will be instinctively assumed by the patient. This is shown if tracings be taken of the back of a child in the various attitudes of sitting, leaning forward, backward, and sitting unsupported.

The back of the chair should slope backward slightly, forming an angle of 100° to 110° with the seat. The back of the chair should be arched with the convexity forward, the greatest convexity corresponding to the physiological curve in the hollow of the back. The back of the

chair should be constructed so that it will serve as a comfortable support to the whole spine when the child leans backward. The backs of most chairs simply touch the shoulders of children in the upper dorsal region. Liebreich's school chair is designed to meet this end. Staffel has advised the use of a lumbar back rest, which can be secured to a chair at a proper height; it should be narrow enough to fit into the lumbar region.

The following measurements are adapted from Staffel:[1]

	I. 6–9 years.	II. 9–12 years.	III. 12–15 years.	IV. Adult.
Height from seat to floor	33 cm.	37 cm.	41 cm.	47 cm.
Height from seat to middle of lumbar projection of chair	21 "	23 "	25 "	27 "
From edge of seat to vertical line drawn from lumbar projection to seat	26 "	30 "	34 "	38 "

The picture illustrates a form of school chair which will be found to support the hollow of the back. The writing table should be at a height proportionate to the height of the person sitting. The distance from the top of the seat to the top of the table should be one-eighth of the height of a girl, and one-seventh of that of a boy. The height can also be determined in the following ready way: The distance from the olecranon of the bent arm to the seat with two inches added should be the distance from the seat to the top of the desk. The edge of the table should be just over the edge of the chair. The inclination of the top of the desk should be a slope of two inches in a breadth of twelve.

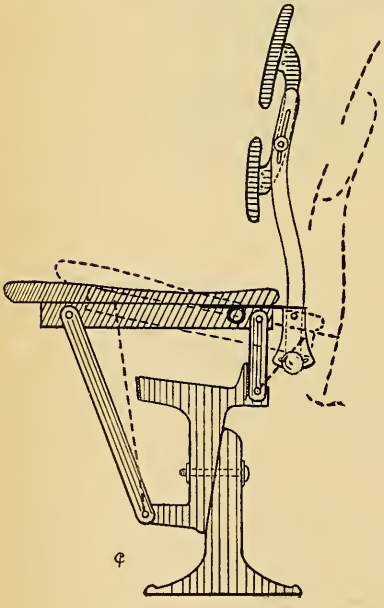

FIG. 120. – School-chair.

A chair furnishing support to the back and permitting a change of position without loss of support has been devised by Professor Miller of the Massachusetts Institute of Technology and Dr. Stone of Boston (Fig. 120).[2]

Attitude during Sleep.—The attitude during sleep is of importance.

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[1] Staffel: Centralblatt f. orthop. Chir., May 1st, 1885.

[2] Trans. Amer. Orthopedic Assn., vol. xii.

To determine the attitudes usually assumed by children, the accompanying observations were made by Brackett, who was allowed, by the courtesy of the superintendent, to examine the decubitus of the children in the Marcella Street Home, Boston.

Three hundred and twenty healthy children were observed with reference to the decubitus while asleep. Of this number 156 were boys, 164 girls. The majority were between six and fourteen years of age, and all between four and sixteen. It was noted whether the child was lying on the back, side, or stomach. In many instances the decubitus was so nearly dorsal that it was a question under what head it should be placed, but none were considered as lying on the side unless the position was such that the pressure was borne on one side of the thorax. In about three-fourths of the number seen, the position was easy, the body straight, and head on the pillow. In several the head was so thoroughly wrapped in the blanket that it could not be removed without almost shaking the child out. Among those not lying on the back, the favorite position was on the side, with the knees drawn up nearly to the abdomen, and the head bent forward toward the thorax. Among the girls, this position was more common and more extreme. One position was seen closely resembling that of the fœtus in utero. The child, a boy of five, was sitting on the right buttock, with the body thrown forward and to the right side, with the knees in apposition to the thorax, and the feet crossed. The head had fallen forward, the face resting on the knees, one arm lay across the chest, the right seeming to be under the side. In this position the child was soundly asleep, and required a shaking to be aroused.

The figures show the positions to be about equally distributed among the three—back, right and left side, except with the boys from ten to fourteen, among whom there were a majority on the back. In the others the age did not seem to influence the tendency.

	Age.	Back.	R.	L.	Stomach.
Boys	4– 7	21	24	15	4
"	10–15	41	20	24	7
		62	44	39	11
Girls	4– 8	13	14	15	2
"	8–10	12	17	12	1
"	8–12	19	20	16	2
"	9–14	7	8	6	0
		51	59	49	5

Dr. Hare, of Boston, examined the decubitus of the healthy inmates in one of the penal institutions of Boston, recording the positions observed after 10 P.M., that is, from one to two hours after the time the inmates went to bed.

The results were as follows:

	Lay on Back.	Lay on the Right Side.	Lay on the Left Side.	Stomach.
Men	536	384	321	24
Women	136	74	56	0
Boys	68	73	15	8

The decubitus of the boys in this table is to be noticed.

The frequency of the decubitus on the right side is quite marked, and is explained by the fact that the boys were all required to lie upon the right side when they went to sleep to prevent conversation; two hours later some had turned on the face, some upon the left side.

It will be seen that the most common attitude in sleep is upon the side, but that decubitus upon the back is more common than on either single side. The right side is more commonly lain on than the left, but the difference is slight; young children and men not infrequently lie upon the belly, but the attitude is not assumed by women or growing girls.

The fact that a right-sided decubitus is to be avoided in a right dorsal convex curve makes these facts of value.

Faulty attitudes are frequently assumed in walking and in standing, especially by young children. The habit of standing upon one leg is usually a habit, but in some cases it may be due to a muscular weakness of one limb or of a knee or ankle. The habit is to be corrected, if possible, by drill or by muscular exercise.

In ordinary cases the precautions at night which should be observed are that the patient should not be allowed to sleep with many pillows, and that the bed should be a firm one. The child should not be allowed to assume a twisted position, but should lie upon the back or the side of the greatest concavity. In threatening cases measures are necessary to preserve a proper position. This can be done by means of bed frames, described under caries of the spine.

Much has been said about the injurious effects of corsets, and there is no doubt that the muscles of the trunk are weakened by the wearing of them.[1] The custom is at present so prevalent that it is difficult to prevent patients from wearing corsets unless under fear of immediate injury. The injury from compression may be made less by seeing that the lacings are elastic and by the use of waists instead of corsets. That growing girls should be furnished with clothing which does not constrict the trunk needs no argument.

Treatment of Lateral Curvature.

Several difficulties are to be met with in treating lateral curvature. As the affection is active during the period of growth, treatment, to be efficient, must be carried on for a long time, and this is tedious to the sur-

[1] Hutchinson: New York Medical Record, April 27th, 1889, p. 464.

geon and irksome to the patient. Furthermore, as the disease is one that does not threaten life and is slow and uncertain in its outcome, it is sometimes difficult to enforce the proper treatment for the requisite length of time. Again, the distortion and danger vary at different periods of the trouble, and consequently methods which are necessary at certain stages of the affection are not needed later on.

As has been said above, lateral curvature is a curve and torsion of the spinal column, due to the superincumbent weight falling irregularly upon a weakened spinal column which is constantly held out of line. There are four ways in which an increase of distortion in a growing spine can be prevented:

1. By removing the superincumbent weight.
2. By strengthening the weakened spinal column.
3. By preventing the spinal column from being held constantly out of line.
4. By correction of the curve.

1. *Removal of Superincumbent Weight.*—Recumbency is the only practical way in which removal of the superincumbent weight can be applied for any length of time, as suspension must be a temporary measure. Recumbency constituted the chief method of treatment of the older orthopedic surgeons.

At present, however, we cannot consider that this is a method of treatment which commends itself for continuous use in the treatment of lateral curvature, for, if prolonged for any great length of time, it necessarily injures the patient's general condition, weakens the muscles, and does not promote the formation of solid bone in the spinal column, so that the weight can be borne without the yielding of the column. In cases of very rapid growth or great lack of muscular strength, recumbency, either on the back or in the prone position, may be advisable if carried out to the extent of rest for several hours in the day.

The use of a distracting force, which is described in the works of the older orthopedic surgeons with the intention of obliterating the curve by a direct pull, is inefficient, as the amount of force that can be applied for any length of time is not sufficient to effect substantial results, and unless efficient it may be injurious, as in many instances it weakens the physiological curves more than the more constant pathological one.

The temporary use of suspension by the head can be added as a means of daily exercise, and can be performed by means of the head sling attached to a sliding bar in the ceiling or to a wheel carriage. The employment of this method for the sole and continuous treatment of lateral curvature is of course impossible, as the disease ordinarily runs its course through several years, but in extreme cases such methods may be applied temporarily.

2. *To Strengthen the Weakened Spinal Column.*—Any attempts to

strengthen the bony structure in the present state of our therapeutic knowledge must be limited to the administration of tonics, and an improvement of the digestion and assimilation, and by encouraging exercise and fresh air as far as it is practicable.

The spinal column, however, can be strengthened in its practical power of resistance by increasing the strength of the muscles which hold it erect, by postural and gymnastic exercises.

Postural.—The postural treatment consists in the correction of faulty habits, the development of weak muscles, and the retention of proper attitudes. As a raw recruit is taught the position and carriage of the soldier, so children are to be drilled into standing and walking erect. This method is suited for the simplest cases. To be thoroughly carried out, it requires that the patient should daily be exercised in walking, standing, and sitting properly for a specified time under the direction of some competent person. The principles of the "setting-up" drill of recruits in all armies are applicable, with modifications, to patients of this class. When resting during the hour of drill the patient should remain recumbent. After the drill is over, such precaution should be taken as will prevent the persistence for any length of time of a faulty attitude. This should not be done (out of the drill time) by constant correction, but by the proper arrangement of the play hours, and a supervision of the chairs when reading and studying. Walking, running, and active games should be encouraged, while reading, except in proper position, should be discouraged. A certain amount of time should be given to proper rest of the back. Tight or constricting clothing should be avoided.

The usual bad habits of position are as follows: standing on one leg, sitting at too low a table, sitting in a twisted position, and sleeping always on one side with too high a pillow for the head.

In many early cases the faulty attitudes are clearly the result of muscular weakness. The increase in height has not been accompanied by a corresponding development in muscle. This condition is frequently met in rapidly growing children, and is one of the most common causes of lateral curvature. Here proper gymnastics are indicated, but they should be prescribed and carried out with much care. In cases of gravity, the children are unable to bear much exercise without fatigue. Those exercises, therefore, chiefly needed in correcting the deformity should be the only ones prescribed. The usual class-work of the gymnasia is to be avoided, as such cases require the individual attention of a competent person, who will see that no faulty position is taken during the exercises.

Each case may be regarded as far as exercises are concerned as a separate problem to be worked out individually. Those exercises are to be given which place and maintain the spine in the best position. One way of accomplishing this is by determining first the attitude nearest to normal which in each individual can be voluntarily assumed. This must be

ascertained by experiment. This attitude is called by Mr. Bernard Roth the "keynote position."

All exercises should be done in such a way as to develop the muscles involved in this attitude, or while the attitude is maintained. The following are the exercises which he prescribes, varying in a measure in individual cases:

1. Lying on the back, arms by the side, hands supinated, very slow deep inspirations by the nose, expiration by the mouth.

2. The same, with arms extended above the head.

3. Position the same as No. 1, head rotation, lateral flexion of head.

4. Position the same, simultaneous circumduction of both shoulder joints from before backward, elbows and wrists extended.

5. Position the same, one hip circumducted both ways (knees extended).

6. Lying on back, simultaneous extension of both arms upward, outward, downward, from a position of the elbows flexed and close to the trunk.

7. Lying prone, one hip circumducted both ways, knee kept extended.

8. Sitting on couch, with the back at an angle of 45°, ankle circumducted in, up, and out, while the toes are inward the whole time.

9. Lying on back with arms extended upward by the sides of the head, flexion of both arms (surgeon resisting). (The patient's knees, flexed over the end of the table, fix the trunk.)

10. Patient astride a narrow table, with the arms down and hands supinated, trunk flexion at lumbar vertebræ (patient resisting), followed by trunk extension (surgeon resisting).

11. Patient, with arms extended upward, leans against a vertical post with pegs on each side; these he grasps. The surgeon gently pulls the patient's pelvis forward by his hands on the sacrum (patient resisting), also pelvis rotation on its axis to right and left alternately (surgeon resisting), with the hands on each side of the pelvis.

12. Lying on back with head and neck projecting beyond the end of table the head is gently flexed by the surgeon's hand on occiput (patient resisting).[1]

Light Gymnastics.—It is not a difficult matter to devise simple and practicable exercises to develop the back muscles. The strength of a patient's back muscles can be determined in a ready way by attaching a cord to the front of a cap tied to the head, and fastening this cord to a spring balance. The patient, seated and strapped to a seat at the proper distance from the spring balance, held firmly by an assistant, is directed to bend backward, keeping the back straight so far as is possible, or stoop-

[1] British Medical Journal, May 13th, 1882; and also Walsham: St. Bartholomew's Hospital Reports, vol. xx., 195.

ing to pull with straight legs upon a dynamometer attached to the floor, the amount of the pull being indicated upon the dial.[1] A record of this registers any increase in the strength of the patient, and as a clinical fact it will be found that an improvement in carriage will correspond to an improvement in the indicated strength.

The management of cases of this sort may be described in a general way as follows:

After a careful inspection of the deformity, and an examination as to the flexibility of the curves, and examination of the faulty attitudes, the child's height and weight should be taken and a comparison made with the standards established by Bowditch's tables,[2] or the tables of measure for weight and height mentioned under the head of prognosis, in order to determine whether any excess of growth in height or deficiency in weight exists. It should be considered that if a child has grown with unusual rapidity, or if the height had increased without a proportionate increase of weight, greater care should be exercised in the management of the case. The patient should then be directed and taught to sit and stand and walk in as nearly a normal position as possible, and be drilled to assume this position. It should be the object of the attendant to see that all exercises taken during the exercise hour should be done without an assumption of a faulty attitude. The exercises assigned should vary in each case. Simple exercises not requiring special training in any one school of gymnastics are as follows:

1. The patient sits facing the assistant who holds a strap passing about the patient's occiput (prevented from slipping by a cross strap around the head and chin). The patient bends forward and back, keeping the spine straight. The backward movement is resisted by the assistant.

2. Same as above, except that the straps cross the shoulders.

These exercises may be carried on with a weight and pulley, or rubber exercising-tubes instead of the resistance of the assistant, but the amount of force is less readily regulated. The assistant should correct any arching of the back.

3. The patient stands facing a wall at arm's length from it; places the left hand upon the wall at the height of the chin, the hand being in a direction across the body. The patient, supported by the arm, slowly brings the face toward the arm, bending at the ankles, keeping the whole body in line; the face should be turned so that the left ear touches the hand, and the standing position slowly resumed, the body being still kept from bending at the hips.

[1] By fastening a spring balance to the wall, and an arrangement with pulleys and cord connected to straps fastened to the patient, the actual amount of force in different movements can be estimated.

[2] Reports of the Massachusetts State Board of Health.

4. The patient stands with the heels, back, and occiput against a projecting corner (of furniture or doorway), and places the elbow (the arm being flexed) as far back as possible.

5. The patient, seated on a stool or chair, should place the feet behind, and on the inner side of, the front legs of the chair, and slowly bend sideways; the assistant, resisting on the head, determines the strain on the muscles of either side.

For children accustomed to stand upon one leg, the best exercise is to drill them to stand upon the other for a specified number of minutes, and standing on one leg to lower and raise the body, bending at the knee.

Exercises carrying out the principles advocated by Roth have been recommended by Dr. R. H. Sayre,[1] who describes them as follows:

In beginning the exercises a mat or thick shawl is laid on the floor and the patient lies prone, the arms at right angles to the trunk, palms down, face turned to the convex side, and the back as straight as possible. The patient supinates the hands, throws the scapulæ well back, raises the hands from the floor and lifts the trunk, while the surgeon holds the feet down. This is repeated three times; later on it can be done oftener. The breath should not be held during any of these exercises, but the patient should breathe naturally. If necessary to secure this, she can count out loud while exercising.

With the hands behind the head, the patient raises the elbows from the floor, and raises the trunk as before, the feet being held by the surgeon.

With the hands behind the head and the elbows raised, the body is swayed toward the convex side, the patient trying to "pucker in" the bulging ribs and *not* to bend in the lumbar concavity. The feet are fixed as before.

With the arm on the side of the convexity under the body, the other arm over the head, the heels fixed, the patient raises the trunk from the floor.

Sometimes the arm on the side of the concavity is put on the opposite buttock while the patient raises the trunk. Sometimes the arm on the convex side is put on the buttock, and in cases of marked lordosis, with great stooping of the shoulders, both hands are put on the buttocks while the patient raises the trunk.

The patient now lies on the back, arms at the sides, palms up, and lifts first one foot in the air, while the surgeon makes resistance graduated to the patient's power; repeated, say, five times. The same is done with the other foot, and then with both. The feet are next separated and then brought together once more while the surgeon resists. Each leg then describes a circle, first from within out, then from without in.

If there is special weakness at the ankles, with a tendency to flat-foot,

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[1] New York Medical Journal, November 17th, 1888, p. 538.

the patient flexes the foot and extends it against resistance, and turns the sole of the foot toward its neighbor, the surgeon resisting, and it is then forcibly everted again by the surgeon, the patient resisting.

The patient now lifts the arms from the sides, passing perpendicularly to the floor till they are stretched as far beyond the head as possible and then going at right angles to the trunk and parallel with the floor, returns them to sides palms up. While the heels are held, the patient rises to a sitting position, hands at the sides; then she rises from the floor with the hands behind the head and the elbows at right angles to the trunk.

The patient now stands with the heels together; toes turned slightly out, hands behind the head, elbows at right angles to the trunk; then rises on tip-toe, bends the knees and hips, keeping the back as straight and erect as possible, and rises up once more. With the arm on the concave side high above the head, the arm on the convex side at right angles to the body, she rises on tip-toe, bends the hips, knees, and ankles so as to squat, then rises and stands. All this time care must be taken to push the body as straight as possible, and gradually educate the patient to hold it so, without wiggling during these movements.

Let the patient practise walking in these positions, both on the flat foot and tip-toe, and also step high as if walking up stairs. With the palm of the patient's hand on the convex side against the ribs, pushing them in, with the hand on the concave side she pushes a slight weight up in the air while the body swings so as to straighten out the curves.

Sit behind the patient, fix her thighs with your knees, while she holds both arms above the head and bows toward the floor, keeping her knees stiff while you keep her ribs as straight as possible with your hands.

With the arm of the concave side across the top of the head, and the arm of the convex side around in front of the abdomen, the patient bends to the convex side through the ribs and not through the waist.

The patient sitting with the back toward the surgeon, the latter pushes one hand against the most prominent part of the convexity, and with the other hand passed around the shoulder of the concave side, straightens out the curve as much as possible, the hand on the "bulge" acting as a fulcrum in straightening the curve.

The patient sits on a stool in front of the surgeon, who fixes the pelvis with his knees. The patient then twists the projecting shoulder to the front, while the surgeon holds the elbows, which are at right angles to the trunk, the hands being behind the head, and makes resistance. In the same position the patient swings forward and back, swinging through the hips, keeping the back stiff and not bending in the waist.

The patient pushes in the ribs on the convex side with the hand, and pushes up with the hand on the concave side, the same as when standing. She also lifts the arm of the concave side at right angles with the body while holding a weight.

The exercises should be such as develop the muscles of the back, including the neck; the glutei muscles and others about the hip usually also need exercising, and the abdominal muscles also in most cases.

Suspension as a means of muscular exercise is in all probability of little value, as the muscles which are brought into play are chiefly the arm muscles. The temporary relief of the superincumbent weight which is afforded by suspension may correct the curve in a measure, but the effect cannot be lasting. Suspension will, however, help to relieve for a while, in some severe cases of lateral curvature, the sense of discomfort caused by badly distributed weight falling upon a distorted spine. The same may be said of trapeze and ring exercises.

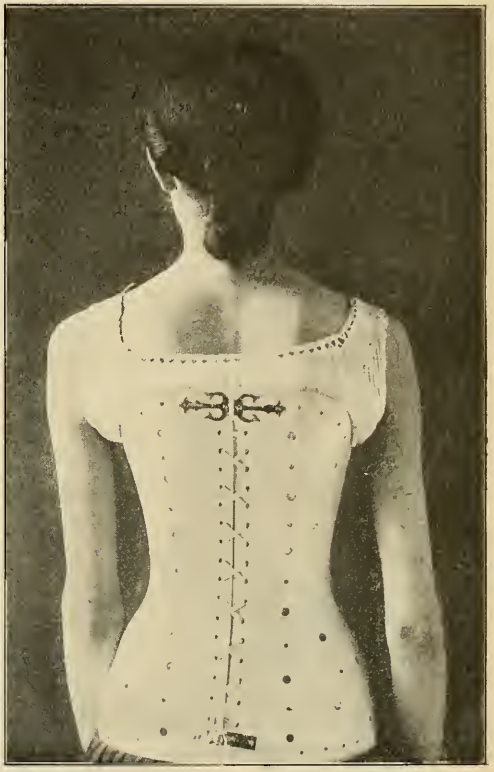

Fig. 121.—Paper Jacket, Hinged. (Weigel.)

The importance of muscular strength in maintaining the erect position suggests the development of certain muscles as a rational method of treatment. When this can be accomplished, and is not prevented by changes in the shape of the bones or contraction of the ligaments or muscles, it is manifestly beneficial.

By development of the strength of the muscles a correct attitude in a flexible spine is more easily maintained.

The amount of exercise and the means used necessarily vary with the patient. Where gymnasia are at hand the various gymnastic appliances can be made of service—but efficient treatment can be carried out by the persistent use of simpler means.

Heavy Gymnastics.—The method of muscular development demonstrated by Sandow has been employed with advantage in cases with weak back muscles. This has been thoroughly carried out by Teschner, of New York.[1]

[1] Annals of Surgery, August, 1895; Orth. Trans., vol. ix.

For success the patient should exercise daily with dumbbells weighing from one-half to five pounds, and three times a week exercises under super-

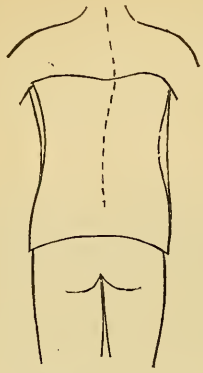

FIG. 122.—Diagram of Plaster Jacket.

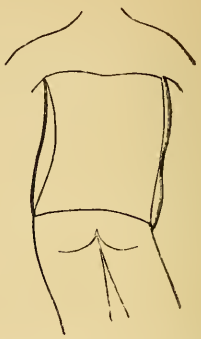

FIG. 123.—Slipping of Plaster Jacket.

vision with heavier weights should be taken. The weight of these heavy bars and bells and the amount of the exercise depend upon the strength, capacity, and endurance of the individual. Each patient is put to his limit of work at each visit, and this limit is extended at each visit. This increase is largely dependent on correctness of posture and precision in the work.

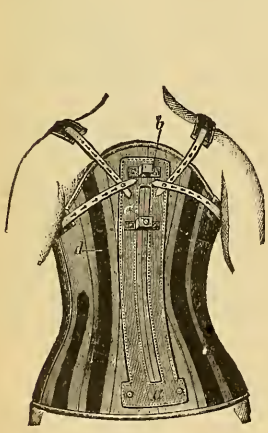

FIG. 124.

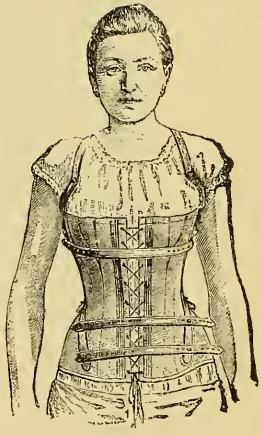

FIG. 125.

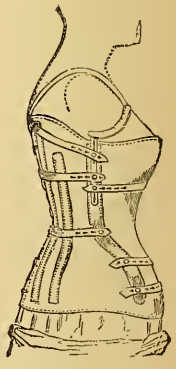

FIG. 126.

FIGS. 124-126.—Beely's Corset. (Schreiber.)

The bells weigh from five pounds upward each, and the steel bars and bar-bells twenty-six pounds and upward. The exercises are as follows:

Bells are pushed from the shoulders above the head alternately as often as the patient's strength permits. The patient swings a heavy

bell with one hand from the floor, above the head and down again, the elbow and wrist being fixed and the motion repeated as often as possible in a systematic manner; then with the other hand the same number of times and later with both. This exerts all the extensor muscles from the toes to the head in rapid succession.

When a heavy ball is pushed or swung above the head on the side opposite the scoliosis, the action of the back muscles is such as to cause the curved spine to approximate a straight line. A similar result is produced when a heavy weight is held by the side of the erect body on the scoliotic side, the arm being at full length.

When a heavy bar is raised above the head with both hands the patient must fix the eyes upon the middle of the bar to maintain the equilibrium. This necessitates the bending of the head backward, the straightening and hyperextending of the spine, and consequently correcting a faulty position with a weight superimposed. The heavier the weight put above the head, whether with one hand or with two, the more the patient must exert himself to attain and maintain a correct or an improved attitude in order to sustain the equilibrium.

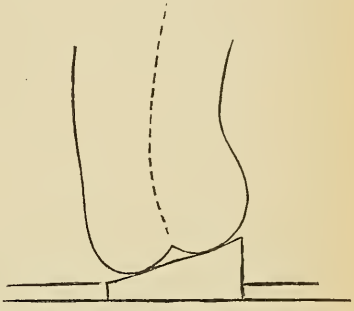

FIG. 127.—Seat Elevated on One Side for Changing Lumbar Curves.

When a patient lying supine upon the floor raises a heavy bar above the head so that the arms are perpendicular to the floor, the weight of the bar, the position and weight of the body, and the action of the muscles tend to broaden the entire back and shoulders, and a slow downward movement tends to widen the entire chest, and most markedly the shoulders. Pushing the bells above the head, swinging them with each hand and with both hands together, raising a bar above the head, standing and lying down, and the exercises above enumerated constitute a day's work.

Whether light or heavy exercises are used, persistence is necessary for success.

3. To Prevent the Spinal Column from being Held Constantly Out of Line.

Fixation Appliance.—It is manifest that during the formative period of growth faulty attitudes are to be avoided. Recumbency being inapplicable for a long period, and gymnastics being possible only for a limited portion of the day, some form of appliance which checks faulty positions is often desirable.

Corsets made of plaster-of-Paris, leather, paper, and celluloid, or cloth stiffened with steel, act as supports and limit faulty positions. Weakening of the muscles from the use of such appliances must be combated by sys-

tematic gymnastics. These appliances should be removable if designed simply as means of preventing faulty attitudes, and are made in the same way as removable corsets for the convalescent stage of Pott's disease, except that they are modelled to correct certain positions and not to fix the spinal column. Such attitudes are chiefly as follows: the dropping of one shoulder, raising the other, curving and twisting the spine to the side.

When side inclination of the trunk exists to such an extent as to make the lumbar curve the chief curvature, raising the pelvis (by placing an increased thickness under the sole of the shoe on the apparently lower hip, and a pad under the lower buttock in sitting) will serve as partial correction.

Corrective Measures.—When shortened ligaments in spinal curvatures are situated so that they serve as a strong check to muscular activity, purely muscular exercises are not sufficient for corrective stretching. Gymnastics, therefore, alone are inadequate as a system of correction in cases of this class, though of use as an adjuvant and as a method of prevention of relapse after correction. It has been proved by clinical experience and by experiments on cadavera that pressure on different parts of the thorax, *i.e.*, on the ribs, is effective in correcting torsion of the spinal column. This may be employed as a means of systematically re-

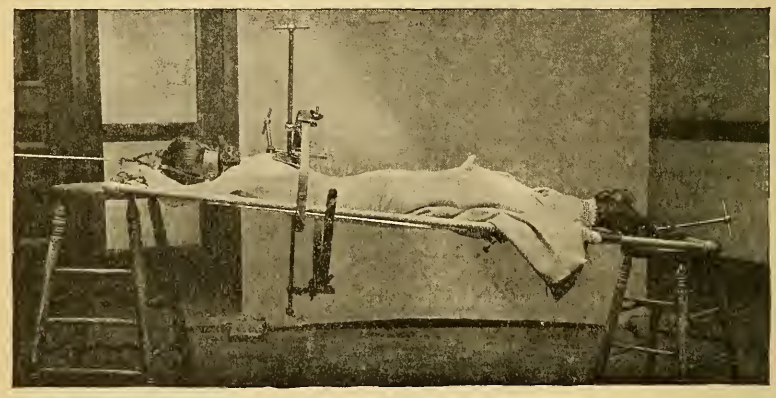

FIG. 128.—Recumbent Pressure Correction Machine. (Children's Hospital Report.)

peated correction similar to that used by those training themselves as contortionists or dancers.

The arrangements depicted in the accompanying illustrations, which are slightly modified from the appliances described by Lorenz, Beely, and Weigel, will be of service for corrective purposes. Daily use of these will be found to correct distortions which simple suspension or recumbency will not affect. The effect of such correction is only temporary, unless the gain be improved upon by fixative appliances or gymnastics.

If the spinal column is arched backward moderate rotation can be made to disappear, and if slight bony or ligamentous change prevents the entire disappearance of the rotation, force can be applied to greater mechanical advantage (by means of appliances) when the patient is recumbent or the weight is taken off of the spinal column than when the patient is erect.

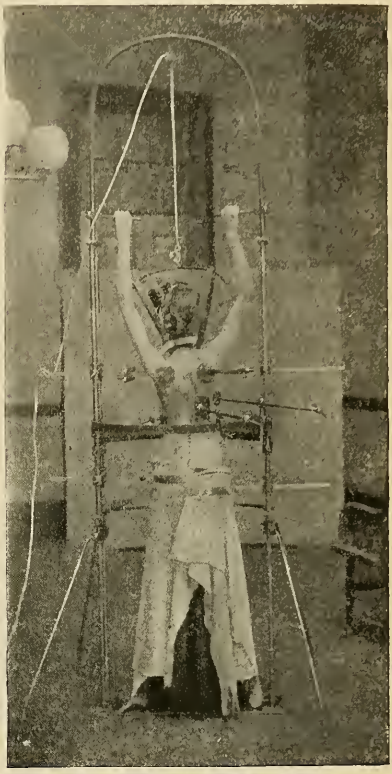

FIG. 129.—Pressure Correction Machine. (Children's Hospital Report.)

The corrective treatment of lateral curvature in the early portion of the stage of development should be therefore an attempt to increase the backward flexibility of the spinal column, especially in that portion where the curve is the most pronounced.

A simple appliance for home use, which should be placed upon a flat lounge, consists of a board a little wider than the patient and long enough to hold the greater part of the patient's trunk when recumbent. At the end of the board should be a wooden bar covered with a padded leather pillow. This bar should revolve on two pivots secured to the board, and the patient should lie with her shoulders upon this padded bar, which should be raised about ten inches from the plane of the board. An assistant should gently pull the patient so that the shoulders will project beyond this roller, and should then direct and assist the patient to raise the arms above the head and bend the head and arms and upper portions of the neck and back as far backward as possible. The patient should then be directed to take deep inspirations and expand the chest as far as she is able; she should now turn so as to lie chiefly upon the projecting shoulder, the assistant pressing upon the projecting ribs in front and the patient breathing as deeply as possible. If the chief curve is in the lumbar region, the lower portion of the back should be placed upon this roller, the legs held down by an assistant, and the patient directed to bend backward as far as she conveniently can.

It is manifest that this method of what may be termed intermittent correction should be accompanied by gymnastics and corsets or appliances maintaining correct attitudes.

In certain cases the curves are too resistant to be altered materially by intermittent correction. If the patient is still at a period of growth, attempts can be made to correct the curves by a method of constant pressure, similar in principle to that used in dentistry to alter the shape of the jaws. For the application of this method, plaster jackets should be applied to the patient in a corrected position.

It is evident that this method of correction is applicable only during the growing period, and it is also true that to be efficient the correcting force should be applied constantly and not intermittently.

In a back of this class it will be seen that there are three points for correcting pressure: one over the greatest convexity; the second point, the

FIG. 130.—Apparatus for Self-correction.

FIG. 131.—Method of Self-correction.

pelvis; and the third, in the upper portion of the trunk between the neck and the scapula on the side opposite that of the greatest dorsal projection. The points for counter-pressure in front are diagonally opposed to the corresponding points in the back, namely, upon the pelvis, upon the shoulder, and upon the thorax. It is found necessary also to arrange that the drooping shoulder should be supported and that there should be a certain amount of lateral correction pressing the neck, side, and the pelvis in the direction of correction. These points necessarily vary in different cases, but the principle that correction pressure and opposing resistant pressure are needed remains the same in all cases of correction in lateral curvature.

No anæsthetic is required, and no pressure is used which is beyond the endurance of the patient without marked discomfort.

The principle of this method of correction consists of utilizing the dependent weight of the trunk supported by plates at the points where correcting pressure in the back is desired. This is accomplished by a method similar to that described in the forcible rectification in Pott's disease, by means of aluminum plates of small size and padded, on which

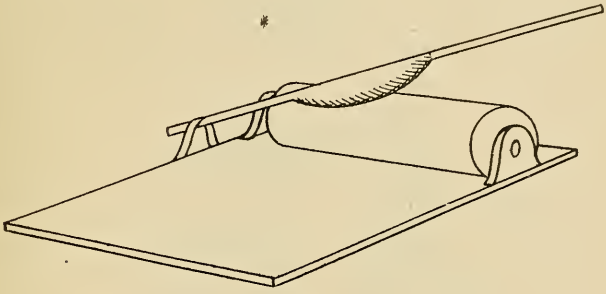

FIG. 132.

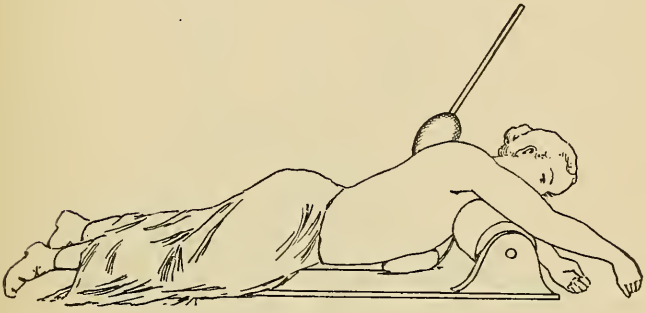

FIG. 133.

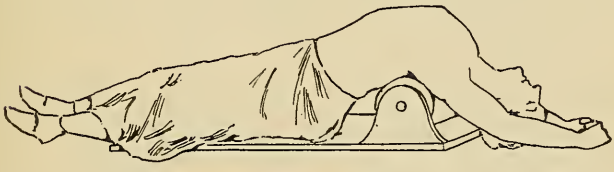

FIG. 134.

FIGS. 132–134.—Apparatus for Forcible Correction of Scoliosis.

the patient lies, resting upon uprights raised or lowered by a screw force at will. These plates support the trunk from falling at the requisite points, viz., the pelvis, the dorsal region at the point of greatest convexity, and at the neck in the region of compensating convexity. The uprights are secured to an iron frame but are adjustable, and cross straps support the head and thighs. Plaster bandages are applied around the

trunk of the patient in this position, and counter-pressure is exerted in front by the hand or by straps upon the projecting shoulder and protruding hip or ribs. Correction of lateral deviation can be furnished by horizontal traction, if necessary, or by side pressure. Felt padding is needed over the portions of the body which are but little protected by fatty tissue; the plaster bandages should be applied high up under the drooping shoulder and over the shoulder from behind, across the neck. When the plaster is sufficiently hardered the patient can be lifted, the

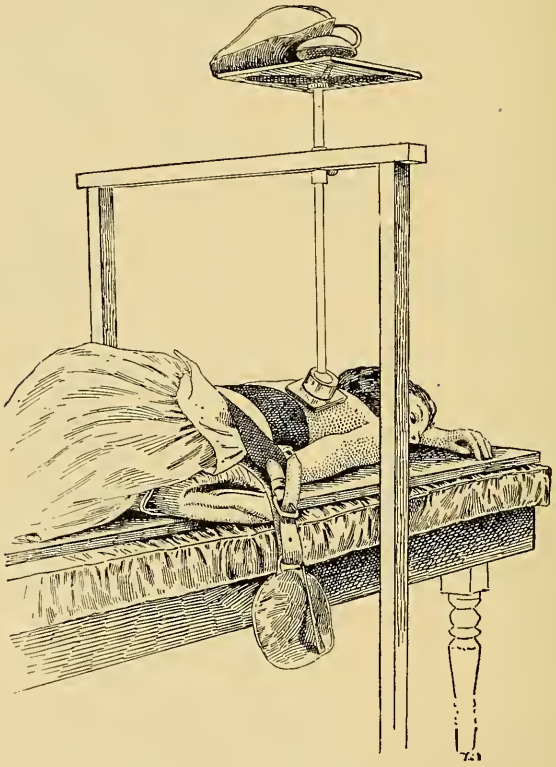

FIG. 135.—Correction by Pressure.

detachable aluminum plates which are thoroughly padded remaining in the jacket. After the patient is placed in the standing position, a steel rod can be incorporated in the plaster in such a way as to carry a strap which passes around the projecting shoulder and draws the shoulder backward, as is seen in the accompanying illustration (Fig. 139). Instead of the plaster passing over the neck, a broad padded strap can be used, arranged as seen in the accompanying illustration. This is lighter and more cleanly than the plaster bandage applied to the neck. If this is properly adjusted it will be seen that the plaster-of-Paris jacket does not tip in such

a way as to exert a pressure upon the hollow portion of the back, as is frequently the case if the plaster jacket is applied in the ordinary way,

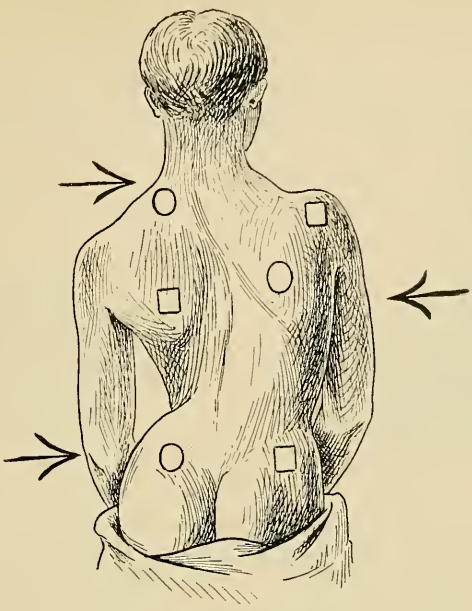

FIG. 136.—Points for Pressure.

as has been shown by Bernard Roth and others. This does not necessitate the use of perineal straps to prevent twisting or tipping of the jacket, but it enables it to exert the pressure upon the chest only in the portions where pressure is desired. It will be found that a removable jacket is not so efficacious as a permanent one, as it is impossible to exert the pressure as efficiently after the jacket is removed. After as much correction

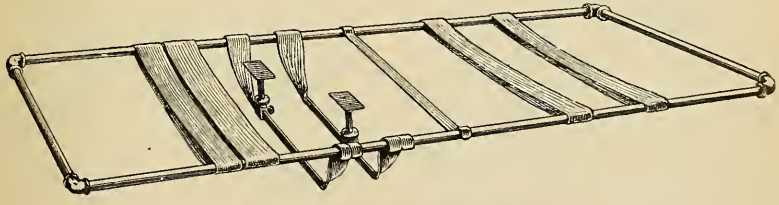

FIG. 137.—Frame for Forcible Correction.

as is possible has been obtained, a removable jacket of stiffened leather or celluloid can be used, accompanied by gymnastics.

This method will be found to be efficient in altering the shape of a distorted trunk, diminishing and correcting both the rotation and side twist in growing children.

When the bones have become hardened by growth, correction is not possible either by intermittent or permanent pressure. The treatment must be palliative and consist of gymnastics, massage, or electricity to relieve symptoms, accompanied or not, according to circumstances, by corsets as a partial support to superimposed weight.

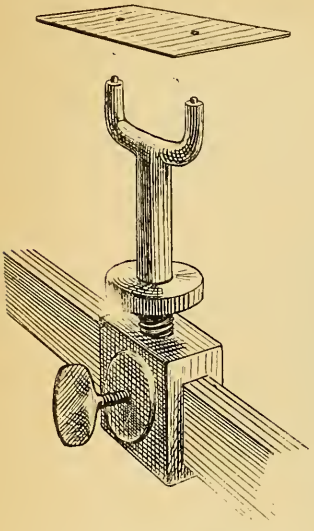

FIG. 138.—Detail of Pad Plate in Frame.

Operative attempts consisting of resection of the projecting ribs, although performed by Volkmann and Hoffa in a few instances, have not yet been accepted as among the recognized methods of practice in orthopedic surgery.

CHOICE OF METHODS.

If the methods of treatment mentioned be recapitulated, they may be summarized as follows: 1, recumbency; 2, postural; 3, gymnastic; 4, fixation; 5, correction. These are severally suited to different classes of cases, and the selection of the proper method or methods will vary according to the patient's condition and the state of the curvature.

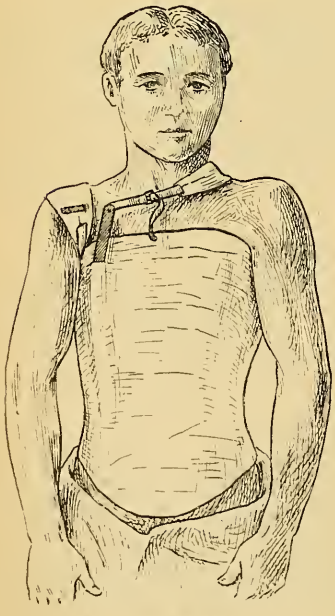

FIG. 139.—Corrective Jacket (Front).

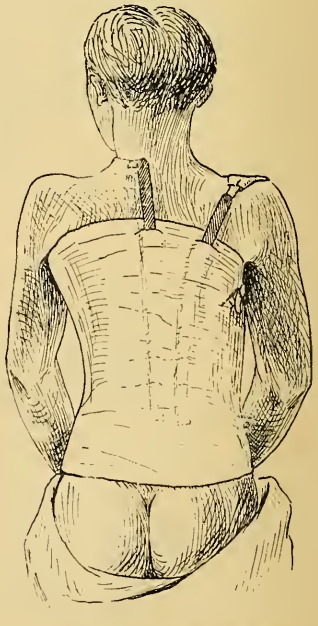

FIG. 140.—Corrective Jacket (Back).

If the back is flexible and no osseous change has taken place; if the curvature entirely disappears when the patient is recumbent or suspended, and is apparently dependent upon habits of attitude, standing, or sitting, the postural method is applicable, coupled with careful selection of school seats, desks, and home chairs.

If to this condition of habitual faulty attitudes weakness of certain groups of muscles is added, proper gymnastics should be employed. If a short leg is present it should be corrected.

If the curves are threatening to increase, and the patient gives evidence of exhaustion, recumbency for several hours a day should be

FIG. 141.—Lateral Curvature before Correction.

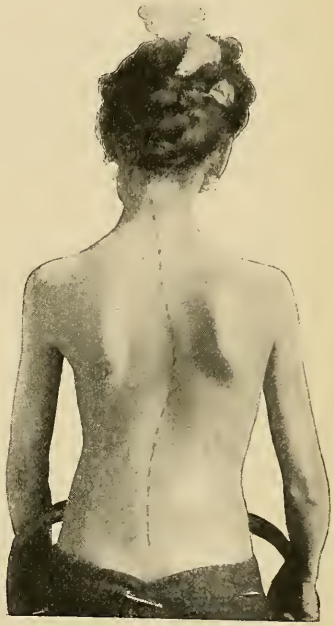

FIG. 142.—Lateral Curvature Three Weeks after Correction.

enforced; and in the worse cases, recumbency should be aided by fixation in improved position by means of appliances. Of appliances, removable plaster jackets, or corsets of that type, will be found the most available, as they are of service in preventing or checking the assumption of faulty attitudes, and as checks to torsion and growing out of the ribs.

Appliances, however, should always be regarded as supplementary to gymnastic treatment, and should be used only temporarily during the period of the greatest increase of the curves.

When the curves are somewhat fixed, but some flexibility still remains, the method of correction, either intermittent or constant, car-

ried out for several months will be found helpful, in addition to gymnastics and postural exercises.

Corsets and mechanical appliances necessarily weaken the muscles of the back, and are to be avoided if possible, and when they are used, massage is advisable in addition to gymnastics.

In the severest types of rigid curves, no corrective treatment is advisable, as the symptoms can be relieved by stiff corsets, or suspension, recumbency, massage, and electricity.

The length of time needed for treatment varies necessarily. In general it should be stated that growing children with a tendency to faulty attitude need careful inspection during the years of growth. The inspection need not be frequent, and will vary from three months to six months according to the rate of growth. In light cases, a few weeks' supervision of gymnastics, followed by monthly or quarterly inspection, is all that is necessary. In more threatening cases, frequent methodical correction and the use of appliances under supervision for several months are desirable.

CHAPTER III.

OTHER AFFECTIONS OF THE SPINE.

Curvatures of the spine.—Kyphosis.—Lordosis.—Spondylitis deformans.—Osteomyelitis.—Typhoid spine.—Traumatic spondylitis.—Malignant disease.—Syphilis.—Spondylolisthesis.—Sprains of the spine.—Hysterical spine.—Distortion of the thorax.

At birth the spinal column is straight and does not present the physiological curves constant in later life.

Physiological curves begin as soon as the child attempts to sit and stand. The cervical and lumbar regions curve forward and the dorsal region curves backward. The cervical curve differs from the others in that it can be obliterated by a change in the position of the head, while the other curves are after early childhood, in part at least, permanent.

These curves vary according to the habits, occupation, muscular system, sex, and figure of the individual. The normal curves are forward in the cervical region, backward in the dorsal, and forward in the lumbar.

The limits of movement in the spine are set by the shape of the vertebræ, the length of the ligaments, and the tonicity of the muscles.

Muscles weakened by disease, by overuse, by too rapid growth, or from any cause, which are unable thoroughly to do the work expected of them, do not prevent an increase of these curves. The spine is longer in recumbency than in the erect position. The amount of this change will be seen by referring to the accompanying table of measurements of the height of eleven people standing, and their length when lying upon the floor on their backs; ten of these were adults and one was a child. The difference was relatively greatest in the child.

Number.	Age.	Height in Erect Position.	Length in Dorsal Recumbency.	Difference.
1	28	5 ft. $8\frac{1}{2}$ in.	5 ft. $9\frac{1}{4}$ in.	$\frac{12}{16}$ in.
2	40	6 " $1\frac{6}{16}$ "	6 " $2\frac{1}{16}$ "	$\frac{11}{16}$ "
3	38	5 " $7\frac{10}{16}$ "	5 " $8\frac{1}{16}$ "	$\frac{7}{16}$ "
4	15	5 " $\frac{3}{16}$ "	5 " $1\frac{1}{16}$ "	$\frac{14}{16}$ "
5	22	5 " 8 "	5 " $8\frac{10}{16}$ "	$\frac{10}{16}$ "
6	29	5 " $8\frac{12}{16}$ "	5 " 9 "	$\frac{4}{16}$ "
7	30	5 " $11\frac{14}{16}$ "	6 " $\frac{4}{16}$ "	$\frac{6}{16}$ "
8	22	5 " $11\frac{5}{16}$ "	5 " $11\frac{12}{16}$ "	$\frac{4}{16}$ "
9	31	6 " 2 "	6 " $2\frac{12}{16}$ "	$\frac{12}{16}$ "
10	35	5 " $4\frac{13}{16}$ "	5 " $5\frac{5}{16}$ "	$\frac{8}{16}$ "
11	$3\frac{1}{2}$	3 " $1\frac{5}{16}$ "	3 " $2\frac{4}{16}$ "	$\frac{12}{16}$ "

Result same in eight other cases in which measurements were not recorded.

When the variations of the normal curves become exaggerated they may be regarded as abnormal and are classed as (1) curvature with convexity backward—kyphosis; (2) curvature with convexity forward—lordosis.

Kyphosis.

This curve is more common in the upper than in the lower part of the spinal column, and may be observed after Pott's disease, in spondylitis deformans (rheumatoid vertebral ostitis), after processes by which the structure of the bone tissue is weakened or altered (such as osteomalacia, rickets, ostitis deformans, and malignant disease of the spinal column), or changed by a constantly assumed bent attitude, or when the muscles of the back are weakened or paralyzed.

Round Shoulders.—The term round shoulders is generally applied to the stooping attitude resulting from faulty growth, or habitual attitude occasioned by occupation. The attitude is well known and familiar. The head is not carried erect but run forward somewhat, the shoul-

Fig. 143.—Side View of Case of Round Shoulders.

Fig. 144.—Contraction of Chest from Forward Drooping of the Shoulders.

ders slope forward, the scapulæ are unduly prominent behind, and the chest appears narrow and flat; in addition the lumbar spine is at times curved forward so that the patient stands with an unduly hollow back; at other times the curve of the lumbar spine does not differ from normal. The deformity is common among rapidly growing children, especially

girls, in whom the skeleton has grown more rapidly than the muscles. Although the faulty attitude may be corrected, it will be again assumed, owing to a lack of strength of the muscles to maintain the corrected position. In some instances shortening of the ligaments exists, holding the spine and ribs in a distorted position. Occasionally the arms are held forward, and if an attempt is made to bring the uplifted arms to a vertical position, this can be done only by arching the spine forward in the lumbar region, owing to contraction of the muscles and ligaments in the front of the chest.

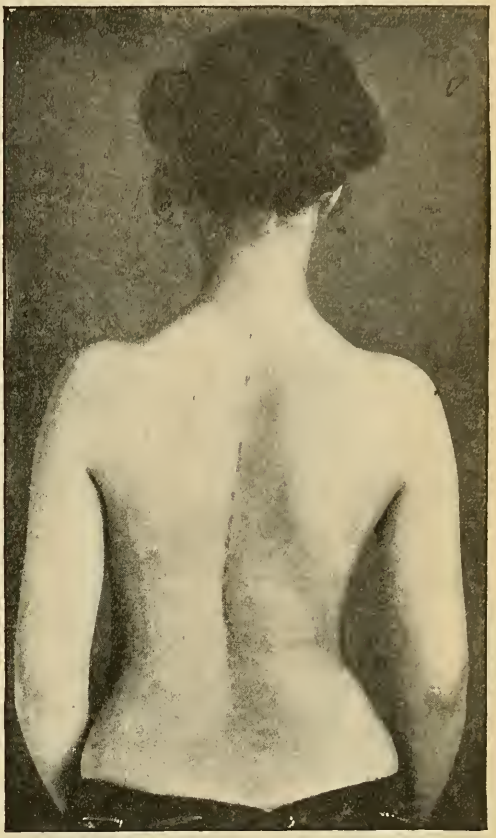

FIG. 145.—Photograph Showing Depression in the Outline of the Shoulder from Shoulder Straps.

A common etiological factor in these cases is the stooping attitude assumed by school children sitting for many hours of the day in positions which stretch without developing the muscles of the back. The attitude may be and frequently is favored by clothing, the weight of which is thrown by shoulder straps upon the shoulders, and in many instances to this is added the pull of side stocking supporters, fastened tightly to a waist with the shoulder straps, so that the child's shoulders are strapped forward.

Occupation.—An increase in the dorsal curve is noticed in certain occupations. Tailors, who sit cross-legged with the spine bent, and cobblers, who bend over their work, are two classical examples of this type of curvature. A curve from a similar cause is seen in school children who bend over their work, sitting at desks of improper height and in chairs of improper construction; it is not unfair to class this as kyphosis of occupation.

Old Age.—A marked form of kyphosis is seen in the round shoulders

common in old age, when, with the general wasting of the tissues, absorption of the intervertebral discs takes place and the vertebral column assumes a greater curve than normal in the dorsal region.

Osteomalacia.—A rare form of kyphosis is seen in osteomalacia, in which the whole spine may be bent so that it forms one long arch with the

FIG. 146.

FIG. 147.

FIG. 148.

FIG. 146.—Attitude of Child; Projecting Abdomen, Hollowing in the Back and Bending Neck Forward. The skirts, buttoned on the waist, exert a forward pull on the shoulders.

FIG. 147.—In Raising the Arms the Back is Bent Forward in the Lower Dorsal Region.

FIG. 148.—The Exostoses Occurring in Senile Kyphosis. Antero-posterior section. (After Beneke.)

convexity backward. In one severe case examined by one of the writers the curve was so great that the chin rested on the umbilicus.

Ostitis Deformans.—In this condition a kyphosis is characteristic. There is commonly a bowing forward in the spine more prominent in the cervical and upper dorsal regions, while the lumbar region loses its concavity and becomes straighter than normal, the head drops toward the chest, the shoulders are round and stooping. The spine may be rigid and painful; there may also be scoliosis in this condition. The body is shortened in the erect position by the curvature and the walk is with the trunk bent forward. The attitude resembles that in spondylitis deformans, but it must be remembered that in ostitis deformans the joints are as a rule exempt and that it is a chronic inflammatory disease, most often of advanced life, affecting, besides the spine, the long bones, the cranium, and the pelvis. It is characterized by pain, hypertrophy, and

softening of the bones so that the bones which sustain weight become curved.[1]

Rickets.—A backward bending of the spine which involves generally the lumbar as well as the dorsal spine, occurs often in young children with acute rickets. In this condition the whole spine is convex backward and the point of greatest curve, which at times appears angular, is at the junction of the lumbar and dorsal regions. It is often difficult to diagnosticate from Pott's disease, and one must depend upon the general symptoms of rickets to establish the diagnosis. At times the prominence dis-

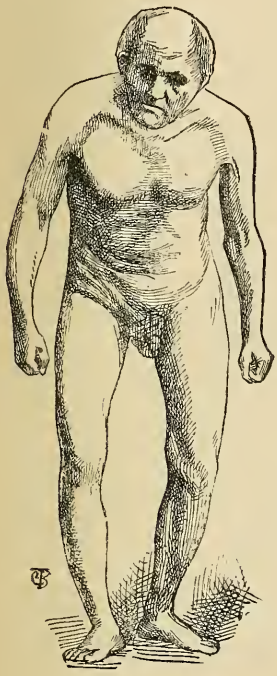

FIG. 149.

FIG. 150.

FIG. 151.

FIG. 149.—Ostitis Deformans. (Lunn.) FIG. 150.—Ostitis Deformans. (Hutchinson.)
FIG. 151.—Femur in Ostitis Deformans. (Humphrey.)

appears upon laying the child on the face and hyperextending the spine, but at other times the spine is stiff and unyielding as in Pott's disease.

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[1] Paget: Med. Ch. Trans., 1877, 37, lx.; *idem*, Med. Ch. Trans., lxv., 1882, 225; *idem*, Tr. Path. Soc., xxxvi., 1884, 382; Stilling: Virch. Arch., vol. 119, 542; Pie: Rev. de Chir., 1897, 169; Taylor: Tr. Am. Orth. Assn.; Thibierge: Arch. Gén. de Méd., January, 1890, p. 52 (excellent bibliography); Paget: Ill. Med. News. 1889, 181; Edmunds: Ill. Med. News, 1889; Lunn: Ill. Med. News, 1889; Robinson *et. al.*: Ill. Med. News, 1889; Watson: Johns Hopkins Bulletin, 1898, ix., 133; Fielder: Trans. Path. Soc., 1896, 47, 190.

The treatment consists in recumbency on the back during the active period of rickets, and on assuming the erect position some form of steel antero-superior support for the spine may be needed. Poorly nourished infants with weak muscles often sit in a position resembling this deformity of rickets, but the back is perfectly flexible and correction occurs on lying down.

Paralysis.—A very marked bending backward of the whole spine, generally with obliteration of the lumbar curve, is sometimes seen with paralysis of the back muscles, either after anterior poliomyelitis and similar affections of the muscles, or in the advanced stages of pseudo-muscular hypertrophy, progressive muscular atrophy, or syringomyelia. In these cases the patient sits with the head resting almost on the knees, the whole back forming one curve with the convexity backward.

FIG. 152.—Skull in Ostitis Deformans. (Mansell-Moullin.)

FIG. 153.—Kyphosis in Advanced Paralysis of the Back Muscles.

In acromegaly kyphosis may exist with consolidation of several of the vertebræ.[1] Kyphosis may also exist in pulmonary osteo-arthropathy.

LORDOSIS.

Lordosis is the name applied to the increase of the physiological curve forward in the lumbar region. This exists in various abnormal conditions, and the amount of curve, of course, varies in normal individuals from those who have very flat backs in the lumbar region to those who have a very markedly hollow back. In certain cases in which the individual is perfectly normal a very marked lumbar curve exists. It is hardly necessary to do more than mention the various conditions in which lordosis exists.

1. Lordosis often exists in connection with the kyphosis of the dorsal

[1] Osborne: Trans. Assn. Am. Physicians, vol. xii., p. 271.

spine spoken of in connection with round shoulders; here it is compensatory to the dorsal curve and the result of muscular weakness.

2. Lordosis also exists in pregnant women and often in persons with large abdomens, due to accumulation of fat or to distention, such as ascites and abdominal tumors. In these cases it is simply the balancing of weight in which the centre of gravity is brought over the centre of support.

3. Increased lumbar curve also exists as the result of training in professional gymnasts, especially in backward contortionists. Such persons habitually walk with a marked degree of lordosis.

4. In conditions in which the abdominal or the back muscles are paralyzed the attitude of lordosis is the result of an attempt to balance the weight of the upper part of the body without bringing a strain upon the muscles. In paralysis of the abdominal muscles lordosis exists.

5. In Pott's disease of the lumbar region apparent lordosis may be one of the first symptoms to be noticed.

6. In cases of double congenital dislocation of the hip lordosis generally exists, because the point of support of the femur on the pelvis is oftenest back of the acetabulum, consequently the pelvis rotates on a transverse axis, carrying the lumbar spine forward.

7. Lordosis exists in many cases of severe rickets on account of the rotation of the pelvis on a transverse axis, as will be described in speaking of rickets.

8. In hip disease, in which on account of a muscular rigidity or adhesions one leg is flexed upon the pelvis in the position of flexion of the leg, the pelvis rotates on a transverse axis and the lumbar spine is carried forward. In that way the patient is able to stand or lie with the legs in the same plane. As recovery from hip disease with the leg slightly flexed is not unusual, nor altogether undesirable if ankylosis must be present, this form of lordosis is fairly common. In double hip disease with flexion deformity the lordosis may be extensive. Contraction of the hip, for any reason, as in infantile paralysis, causes lordosis.

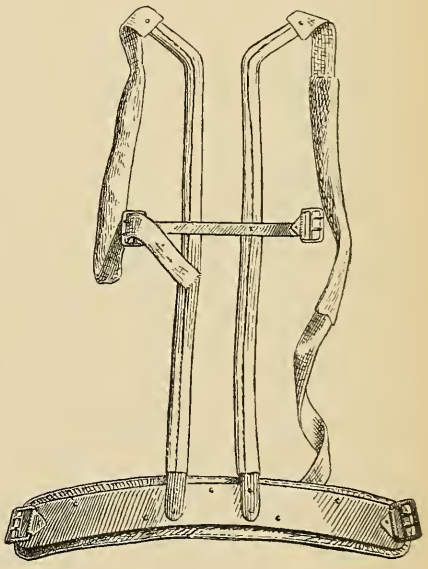

FIG. 154.—Tempered Steel Uprights for Round Shoulders.

9. Lordosis may exist in coxa vara, both secondary to the distortion at the hip and as another manifestation of the rhachitic change.

10. In spondylolisthesis lordosis is very marked.

Treatment.—The treatment of these curves is necessarily dependent upon the causative conditions and attendant circumstances. In rapidly growing children it is desirable to correct faulty attitudes in sitting too long at school studies without a change of position, and to remove constricting clothing. The chief treatment will be gymnastic directed in part to the development of the strength of the back muscles. The exercises described for lateral curvature can be adapted for round shoulders and hollow back.

Occasionally appliances are needed to maintain proper attitudes, but these are to be avoided if possible and reserved for exceptional cases.

The same can be said of recumbent treatment, which is to be only occasionally employed, although a daily rest in the recumbent position is advisable in the case of rapidly growing and muscularly weak children of this type.

Spondylitis Deformans.

Spondylitis deformans is a condition characterized chiefly by an ankylosing affection of the spine with more or less involvement of other joints. The pathological process is in a general way similar to that seen in rheumatoid arthritis, or, as it may be called, arthritis deformans, and most authorities[1] do not separate the two conditions, except that in spondylitis deformans the affection generally first attracts attention in the spine. Marie[2] would separate the condition from arthritis deformans in general on the ground that the former attacks the spine, shoulders, and hips while the joints of the extremities may remain free. He describes six cases (three of them personal observations) and names the condition spondylose rhizomélique.

Spondylitis deformans is also called spondylosthesis deformans, ankylosis of the spine, rheumatism of the spine, arthritie deformante du rachis, and Verwachsung oder Steifigkeit der Wirbelsaule.[3] It occurs in children, but most often in young male adults, and in many cases is preceded by a history of gonorrhœa. In a case, however, reported by Marie (a gonorrhœal inflammation of the spine), the cervical region was the one

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[1] Ziegler: "Path. Anat.," Sec. i.–viii., English edition, p. 273.

[2] Revue de Méd., April, 1898, p. 285.

[3] Bechterew: Deutsche Zeit. f. Nervenheilk., 1897, xi. 327; Beer: Wiener med. Blätter, 1897, xx., 127; Bradford: Ann. Anat. and Surg., 1883; Hutchinson: Arch. Surg., 1896, vii., 246; Oppenheim: "Lehrbuch der Nervenkr."; Ziegler: "Path. Anat.," Bd. ii., 228; Beneke: Festschr. f. LXIX. Versamml. deutsch. Naturf. u. Aerzte, 1897, p. 109; Marie: Rev. de méd., 1898, p. 288.

chiefly affected and the involvement progressed downward. The affection in other respects was similar to that to be described.

The pathological process must be judged from museum specimens and is not to be distinguished from that in arthritis deformans, except that ossification of the fibrous perivertebral structures and even fusion of osteophytes seems to be the chief feature, rather than any great amount of change in the joint surfaces. Specimen 69 in the Musée Dupuytren shows this, and is characterized by ossification of the prevertebral and spinous ligaments. Periosteal proliferation is apt to be marked, and the vertebræ are united to each other by osseous bridges (Ziegler).

The apparently primary involvement of the spine is in marked contrast to the ordinary distribution of rheumatoid arthritis.

There is, however, another class of cases probably, as to which we have no pathological data, in which the muscles and soft parts are implicated. Pasteur reported one such case in 1889, in which scleroderma seemed to play a part, and Beer points out the similarity of this to the more usual cases. For certain cases of his own he assumes a change in the soft parts, whether vaguely related to scleroderma or not, as primary, and is inclined to blame "Muskelschwielen" as at least part cause. The results of massage and electricity which he reports certainly lend probability to this view.[1]

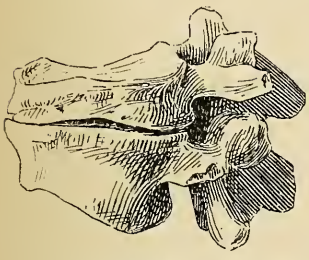

FIG. 155.—Ankylosis of Vertebræ, Articular Processes Primarily Affected; Absorption of Vertebral Bodies. (Specimen in Warren Museum.)

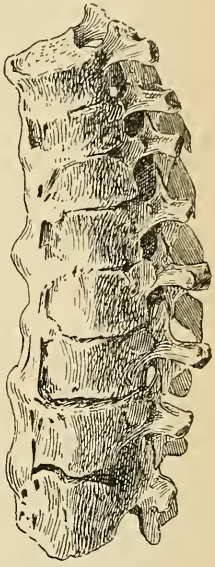

FIG. 156.—Ankylosis of the Spine. (Specimen in Warren Museum.)

The affection is clearly a primary ankylosing arthritis of the vertebral column, accompanied by manifestations of a disease which resembles rheumatoid arthritis.

Adams,[2] in his classical monograph on rheumatic gout, mentions spinal rheumatism as occurring in severe cases affecting other joints, the distortion sometimes being so severe as to interfere with locomotion.

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[1] "Rheumatisme Blennorrhagique" (N. Dict. de Méd. et Chir., Blennorrhagie). Nolen: Deutsches Archiv f. klin. Med., No. 8, 1882, p. 120. Ferron: Thèse de Paris, 1868, No. 211.

[2] Annals of Anatomy and Surgery, Brooklyn, 1883, vol. vii., p. 6.

The deformities of the vertebral column following spondylitis deformans may sometimes exercise compression upon the nerve roots.

Pain in the spine is present in an acute or chronic form, sometimes aggravated by every jar and paroxysmal in character. In other cases pain may be a subordinate symptom, and may be little complained of.[1] Stiffness of the spine is the characteristic symptom. The lumbar curve is obliterated while the dorsal curve is increased, and the patient walks more or less bent over by the dorsal kyphosis, with a gait somewhat like that of Pott's disease. In stooping the motion is entirely from the hips. In lying down the curves are not affected or obliterated. The lower spine is said to be first affected and the cervical last. In the severest cases the spine is stiff from the sacrum to the occiput, and permits no more motion than would an iron rod. In the severer cases the ribs are ankylosed at their junction with the spine, and the chest wall scarcely moves in inspiration, or it may be entirely stationary and the breathing is wholly abdominal. As the cervical vertebræ are usually the last to be affected, motion of the head may be possible after the dorsal and lumbar regions have become rigid. In less severe cases the spine is not involved to the whole extent, but marked stiffness without angular projection exists in a portion of the column. Stiffening and flexion of the hips is common, and leads to a most distressing gait in which the whole body is carried bent forward. Some stiffness of the shoulders is generally an early symptom.

The course of the disease is chronic in the extreme, and its duration covers many years. The bone inflammation has no destructive tendency and accomplishes nothing more than stiffening the vertebral column. The impairment of the general health consequent upon this is generally not so severe as one would anticipate.

The diagnosis of the affection can be made by recognizing the rigidity of the entire vertebral column without the angular prominence of Pott's disease, nor does the latter affection so stiffen the whole column, but only the diseased region. Pott's disease involving the whole or a large portion of the vertebral column would soon lead to very marked results in its destructive tendency. The immobility of the ribs is a pathognomonic sign of the affection, and the involvement of other joints would merely confirm one's opinion of the character of the disease. The early stages of the affection have never been seen by the writers and have not been satisfactorily described.[2]

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[1] Pain may be at times due to compression of the nerve root (Oppenheim).

[2] Braun: "Klin. und Anat. Beiträge z. Kenntniss d. Spondylitis Deformans;" Transactions of the London Clinical Society, 1879, p. 204; Rosenthal: "Diseases of the Nervous System," American translation, 1879, p. 225, Putzel: "Functional Nervous Diseases," p. 133; Brodhurst: Reynolds' "System of Medicine," vol. i., 960; Delpech: "L'Orthomorphie."

It need hardly be said that the prognosis is unfavorable. The harm done is irremediable and the prospect of checking the disease almost hopeless. The dorsal curvature will probably increase, and if the other joints are involved, the patient's condition is deplorable.

Treatment.—In the matter of treatment very little can be said. The general measures useful in rheumatoid arthritis ordinarily should be faithfully tried. The outlook in this affection is no better than in the other manifestations of these diseases. Electricity to the spine and massage may be of some use in altering conditions of the local circulation. It is useless to try to ward off the approaching ankylosis by manipulation, and the measure is harmful and painful. Hot applications and hot baths sometimes mitigate the symptoms.

When pain is present on motion, mechanical support is indicated.

An acute form of rheumatic inflammation of the vertebral articulations has been mentioned, but such a form is rare.

Acute spinal symptoms may exist in connection with gonorrhœa, occurring as described by Finger,[1] and characterized by girdle pains, increased reflexes, tenderness and muscular spasm of the spine, paræsthesia of the legs, and similar symptoms.

Acute Osteomyelitis of the Spine.

This condition may affect either the anterior or posterior part of the vertebral column; it is of the same general character as acute osteomyelitis occurring elsewhere. It may occur as the result of trauma, as secondary to suppuration elsewhere, or as a condition apparently primary. Four-fifths of all cases recorded have occurred in adolescents. The infection is caused by the streptococcus or the staphylococcus pyogenes aureus. The lumbar spine is most often affected.

The condition is charaterized by rapid onset, high fever, and great constitutional disturbance. Abscess occurs early, and the tissues surrounding the abscess are œdematous. Abscesses may occur from the transverse processes and extend both forward and backward. Posterior abscesses are

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[1] Finger: "Blennorrhœa," p. 333, quoting Myrtle, Strümpell, Fournier, Hayem, and Parmentier; Marie: Rev. de Méd., April 10th, 1898; Vulpius: Monatsch. f. Unfallhk., 1897, iv., 201; Beer: Wien. med. Blätter, 1897, xx., 127; Bechterew: Deutsch. Zeitsch. f. Nervenhk., 1897, xi., 327; Stocker: Clin. Journ., London, May 9th, 1894 (ref. Schmidt); Miles: Lancet, November, 1894; Strümpell: Deutsche Zeitschr. f. Nervenheilk, 1897, xi., 338; Oppenheim: "Lehrbuch der Nervenkrankheiten," 1894. S. 210; Roberts: Phila. Med. Times, 1885, p. 209; Osler: "Pract. of Med.," p. 403; Henle: Deutsche med. Wochenschr., 1894, Vereinsbeilage. S. 20; Pasteur: Clin Soc. Trans., vol. xxii.; Goldthwait: Orth. Trans., vol. xii.; Müttener: Deutsch. Zeitschr. f. Kinderheilk., 1898, xiv., 144; Thayer: Phila. Med. Journ., 1898, ii., 955 (with account of twenty autopsies).

accessible for operation; anterior abscesses are almost impossible to locate. Abscess occurs in practically all cases. Paralysis was present in one-third of the recorded cases. Secondary centres of suppuration are likely to occur in other parts of the body. Deformity of the spine is not of very frequent occurrence. It must be remembered that although the process is rapidly destructive the formation of new bone is equally rapid, and that the severity of the disease necessitates the recumbent position during the acute stage.

The mortality has been said to be as high as sixty per cent, but this cannot be accepted as accurate as the less severe forms of the affection may often have been overlooked.

Direct incision to the bone furnishing drainage is indicated as soon as is possible. During convalescence the spine should be supported as in Pott's disease.[1]

Typhoid Spine.

The term "typhoid" spine was applied by Gibney to a condition of the spine simulating Pott's disease, except in the matter of deformity, which occurs occasionally after typhoid fever. It was thought by Gibney to be due to an inflammation of the structures surrounding the vertebræ (perispondylitis). In the cases described by Gibney excessive pain and stiffness of the back were present and at times sensitiveness. His cases made good progress with one exception, in which a slight impairment of the gait persisted.

The affection is to be regarded as of the class of infectious bone processes following typhoid, as described by Keen, Park, and others.

Quincke reported two cases, both of which recovered.[2]

Traumatic Spondylitis.

Under this name Kümmell described, in 1891, an affection of the vertebral column following injury, resembling Pott's disease most closely, but assumed to be of a non-tuberculous character. Very few autopsies have been brought forward as demonstrating the non-tubercular character of the affection.[3]

The kyphus is said to be generally larger and more rounded than in

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[1] Müller: Deutsche Zeitschr. f. Chir., xli.; Hahn: Beiträge zur klin. Chir., xlv., Hft. 1; Makins and Abbott: Ann. Surg., May, 1896; Chipault: Gaz. des Hôp., 1897, lxx., 1442; Riese: Centralbl. f. Chir., 1898, S. 585; Tixier: Le Bulletin méd., July 21st, 1895.

[2] Quincke: Mitth. aus den Grenzgeb. der Med. und der Chir., 1898, iv., 244; Gibney: Orth. Trans., vol. ii. and iv.; Osler: Johns Hopkins Hospital Reports, iv., 80.

[3] Staffel: Monatschft. f. Unfallhk., 1897; Chipault: "L'Apophysalgie Pottique," Travaux de Neurologie Chir., 1898.

tuberculosis, and there is said to be generally a long interval between the injury and the symptoms. It is said that abscesses do not occur (Hettemer). Partial paralysis has been present in many of the cases described.

It is obvious that after the fracture of the spine a kyphus may exist. If the patient is allowed to go about before the callus has become firm, this kyphus may increase. König held that all cases were limited to this. Kümmell believed that a rarefying ostitis was the cause of traumatic spondylitis; Henle assumed an osteoporosis or a process analogous to osteomalacia, and speaks of the possibility of a trophic and vasomotor disturbance due to lesions of the central nervous system. Wagner and Stolper[1] speak of the mechanical shutting up of damaged vertebral bodies when subjected to increased pressure.

As this affection, as described, is considered a destructive ostitis of the vertebræ, following an injury after a long interval, it is a question if it deserves the separate classification given to it, differing so little as it does from the usual course of caries of the spine in symptoms and treatment.[2]

Malignant Disease of the Spine.

Sarcoma and carcinoma of the vertebral column are occasionally met. Sarcoma may be either primary in this location or secondary to some deposit elsewhere. Carcinoma is probably secondary always.

Sarcoma in several reported autopsies has been found to be of the large-celled type. Michel[3] has described these under the head of "tumor myéloïdes." Cysts or cavities, with fluid or semi-fluid contents, are frequently found, and he has suggested a relation between this and hydatid cysts, but this can hardly be sustained. Carcinoma has been noted following similar disease of the breast and testicle, and less frequently of the stomach. The occurrence may be from direct extension, or from general infection.

The disease usually begins as an infiltration of the spongy tissue of the vertebral bodies, which is gradually replaced by the malignant growth. There may be but little change in the appearance of the bodies, but these will be found converted into a soft, friable mass. Destruction of the bone substance with deformity may occur. Small growths exter-

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[1] Deutsche Chirurgie, Lief. xl., p. 244.

[2] Hettemer: Beitr. z. klin. Chir., xx., p. 103 (with full bibliography); Kirmisson: Rev. de Chir., 1896, 481; Kocher: Mitth. aus den Grenzgeb. der Med. u. d. Chir., 1895-96, p. 448; Henle: *Ibid.*, 1895-96, Hft. 3; Heidenhain: Monatschr. f. Unfallheilkunde, iv., 3, 65; Schneller: Münch. med. Wochenschr., xliv., p. 2, Vulpius: Monatsch. f. Unfallheilkunde, iv. 7. 201; Kirsch: *Ibid.*, iv., 5, 140; Bähr: Aerztlicher Praktiker, 1897, No. 17.

[3] "Nouv. Dict. de Méd. et de Chir.," 39, 222.

nal to the vertebræ are sometimes seen, and are likely to be mistaken for malignant disease of the vertebral column.

The most frequent site of malignant disease is in the lumbar region, and the next commonest location is in the dorsal vertebræ (Amidon).

The disease may pursue an insidious course, and not be suspected until found at the autopsy. This, however, is rare, and a serious affection is usually evident, even though no diagnosis is made. The chief symptoms are pain and paralysis, and both are the result of the encroachment of the growth on the spinal nerves and cord. Considering the course of the former and the intimate relation to the diseased bone, it is not surprising that pain should be an early and prominent symptom. It is usually increased by pressure and motion. The location of the pain will depend on the site of the diseased vertebræ, and will be accordingly

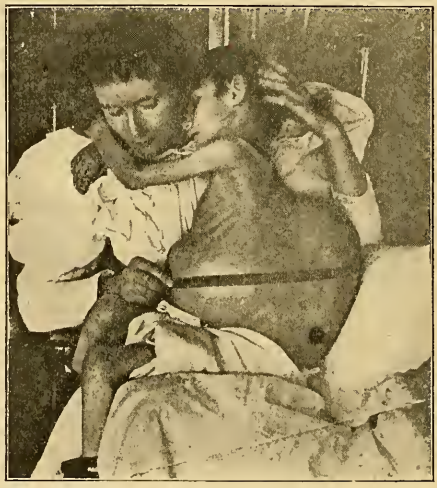

FIG. 157.—Sarcoma of Spine.

in the arms, trunk, or legs. Edes[1] states this symptom may disappear more or less completely at a later period. The paralysis usually follows a disturbance in sensation and is due to compression from extension of the disease, or from involvement of the meninges. It may be partial or complete, and as a rule does not occur suddenly. The occurrence of œdema from thrombosis in paralysis rather favors the theory of this disease as the cause.

Tenderness over the spine is an uncertain sign, and probably has no more diagnostic importance than in ordinary spinal caries. It was noted as present in seven of Amidon's twenty-four cases. When deformity

[1] Edes: Bost. Med. and Surg. Jour., June 17th, 1886, 559.

occurs it will be found to present a more rounded prominence than is usually seen in Pott's disease. Hemorrhage from the bowels or hæmaturia has been observed.

Charcot[1] gave the name of "paraplegia dolorosa" to the condition which he had observed to follow infiltration of the vertebræ, more particularly those cases seen by him after cancer of the breast, which revealed the existence of this disease, which was otherwise latent. These symptoms consist of pain, chiefly in the lumbar region, and radiating through the lower limbs. In character these pains are lancinating. There is formication, sense of constriction about the waist, no anæsthesia, but on the other hand there is frequently hyperæsthesia. Walking is usually interfered with, but complete paralysis does not occur. The bladder and rectum are not affected, and there is a marked vasomotor disturbance, as shown by the tendency to rapid formation of bedsores, etc.

When following malignant disease elsewhere, which can be recognized, the diagnosis should present no special difficulty, but in other instances is usually hard or even impossible. It should be distinguished from aneurism of the aorta, cervical pachymeningitis, and Pott's disease.

The prognosis needs no comment, a fatal end is only a matter of time.[2]

Syphilis of the Vertebræ.

Syphilitic destruction of the bodies of the vertebræ must be considered as possible and not unlikely, but the recorded cases of this sort are not in general satisfactory as proving pathologically that such a condition has existed. The presence of syphilis in a patient with a knuckle in the back does not prove that tuberculosis is absent or that the vertebral destruction is of a syphilitic character.

The best authenticated cases are as follows: Jürgens, a case in which at autopsy syphilis of the cervical vertebræ was found. Paralysis had existed during life. Lewin, a case of gumma of the axis; König, a case of syphilitic granulations of the spinous processes.

The occurrence of gummata of the vertebræ or near them in such position as to cause pressure on the cord must be admitted, also the syphilitic origin of certain vertebral exostoses. Gowers cites a case of syphilitic caries of the spine, but it was secondary to pharyngeal ulceration.

The diagnosis of syphilitic spondylitis in most cases has rested on the slenderest clinical evidence, which cannot be accepted (cases of Jasinski, Ridlon, Staub, Lewot, Leyden, etc.). Under these circumstances nothing

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[1] Charcot: Comptes rendus de la Soc. de Biol., 1865, 28.

[2] v. Bechterew: Neurol. Centrabl., 1893, 313; Föderl und Peham: Deutsch. Zeitsch. f. Chir., xlv.; Dennis: "System of Surgery;" Amidon: N. Y. Med. Jour., 1887, 225; Edes: Boston Med. and Surg. Jour., 1886, civ., 559.

can be said of the clinical course of the affection. The writers are unable to report personal cases.[1]

Spondylolisthesis.

The name spondylolisthesis (σπόνδυλος, a vertebra, and ὀλισθήσις, a gliding) refers to a forward subluxation of the body of one of the lower lumbar vertebræ, with the exception of one recorded case in which the upper part of the sacrum was displaced forward. This displacement has ordinarily been described as a dislocation; in most instances it hardly reaches a greater degree than may be described by the name subluxation. Even this name is incorrect anatomically, because the body of the vertebræ is chiefly affected, while the laminæ and spinous process remain practically in place.

Fr. Neugebauer,[2] of Warsaw, has thoroughly investigated and elaborated the subject. In 1854, this condition was recognized and named by Killian.[3] Blake,[4] Gibney,[5] Lombard[6] and Lovett[7] have contributed American observations.

Pathology.—The pathological condition is fairly constant, degree and location varying within certain limits. The essential part of the condition seems to be the slipping forward of one of the lower lumbar vertebral bodies, while the vertebral arches remain practically in place. This implies, of course, an increase in the distance between the body and the spinous process of such a vertebra.

The commonest form of the displacement is subluxation of the fifth lumbar vertebra in relation to the sacrum. The displacement of the fourth lumbar vertebra in relation to the fifth is next in frequency. The displacement forward of the first sacral vertebra in relation to the rest of the sacrum has been recorded once only (H. von Meyer, Zurich specimen).

The displacement may be slight or extreme. Secondary changes occur in the severer cases. Exostoses may develop about the joints of the displaced vertebræ, apparently elongating them, and the intervertebral

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[1] Staub: Wien. med. Presse, 1896, xxxvii., 1468; Jasinski: Archiv f. Derm. u. Syph., 1891, p. 409; Lomikowsky: *Ibid.*, 1879, p. 334; Oppenheim: "Lehrb. der Nervenkr.," 1894, p. 209; Leyden: Berliner klin. Wochenschr., 1889, p. 461; Fournier: La Semaine méd., 1899, p. 53; Gowers: "New Dis.," 2d ed., p. 261; Ridlon: Orth. Trans., iv., 118.

[2] Neugebauer: "Spondylolisthesis et Spondylizème." Paris, G. Steinheil, 1892. Critical review, description of specimens and cases, complete bibliography.

[3] Killian: "Comment. anat. de S.," Bonn, 1853; "Schilderung neuer Beckenformen, Mannheim, 1854.

[4] Blake: American Journal of the Medical Sciences, 1867, cvii., p. 285.

[5] V. P. Gibney: Medical Record. March 30th, 1889.

[6] Lombard: Boston Medical and Surgical Journal, August 20th, 1885.

[7] Trans. Amer. Orth. Assn., 1897.

joints may be obliterated or the fibro-cartilage may be replaced by an arthrodial joint. The bony arch connecting the vertebral bodies and the laminæ may be either thinned and intact, or it may be separated entirely.

FIG. 158.—Small Pelvis of Prague (Median Section Instance of slight forward displacement of fifth lum bar vertebra. (Neugebauer.)

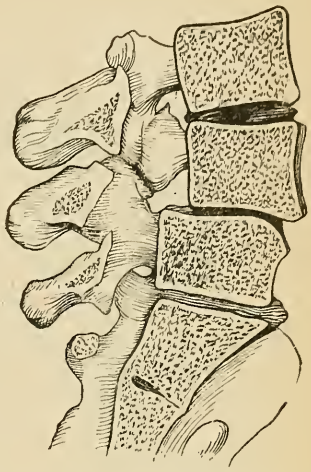

FIG. 159.— Breslau Specimen. Instance of slight forward displacement of the fourth lumbar vertebra. (Neugebauer.)

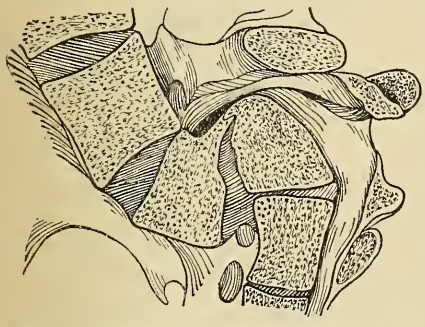

FIG. 160.—Pelvis of Moscow (Median Section). Instance of extreme forward displacement of fifth lumbar vertebra. (Neugebauer.)

This may be a unilateral or bilateral condition.

The causes of separation of the anterior and posterior parts of the lumbar vertebræ are classified by Neugebauer, and generally accepted to be as follows:

Separation of the vertebral arch due to congenital defect.[1]

Separation of the vertebral arch due to fracture.

Disease of the sacro-vertebral articulation.

Bony changes the result of pressure.

Other theories as to etiology may be dismissed[2] as being unsupported by pathological evidence.

Spondylolisthesis is recorded as affecting women more frequently than men, and comparatively few male cases have been recorded. It occurs

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[1] Broca: Bull. de la Soc. d'Anat. de Paris, 1884, p. 448.

[2] Zeitsch. f. Heilk., 1892; Lambl: Cent. f. Gyn., 1881, xi., p. 25; xii., p. 28; 1885, xxiii., p. 356; Virchow's Archiv, 1857, xi., 2, 187; Bohn: Inaug. Diss., Berlin, 1892; "A New Case of Spondylolisthesis, with Successful Delivery;" Olshausen: (*a*) Mon. f. Geb. u. Gyn., 1861, Bd. xvii., p. 255; (*b*) Mon. f. Geb. u. Gyn., 1864, Bd. xviii., p. 190.

almost always at puberty or in young adult life, and the majority of all cases give the account of a severe traumatism, occurring most often during childhood or near puberty. The deformity may follow immediately upon the accident, or it may develop in after years, just after puberty or during pregnancy. Other cases are to be accounted for only

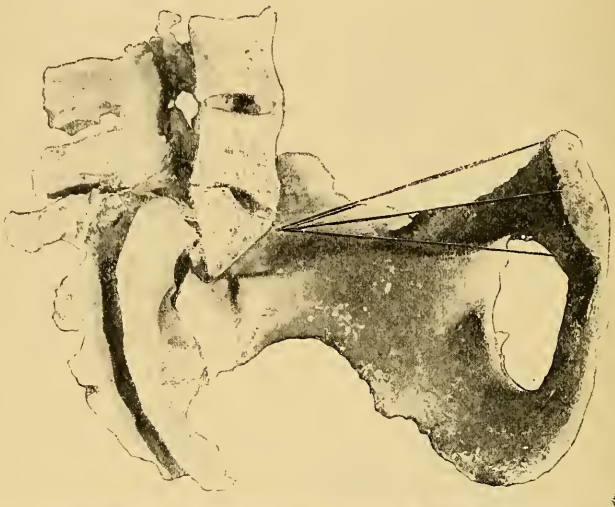

FIG. 161.—Spondylolisthesis due to Vertebral Disease. (Dr. H. B. Cushing, Johns Hopkins Hospital.)

by frequency of pregnancy or by very hard work. In some cases no assignable cause can be found.

The symptoms by which the diagnosis must be made are as follows: A disturbance of equilibrium resulting in a faulty carriage, which is shown chiefly by a sharp increase in the lower lumbar curve in even the mildest cases. More exactly it seems to be a prominence of the iliac crests and buttocks in relation to the lumbar spine. There is no apparent falling away of one spinous process from another, for reasons that have been demonstrated in speaking of the pathology. The spine curves forward sharply from the sacrum, and this gives undue backward prominence to the crest of the ilium and the buttocks. The appearance at first glance is the same as that in cases of double congenital dislocation of the hip. Lateral deviation of the spine may be present. With this lordosis goes a diminution of the obliquity of the pelvis, which rotates on its transverse; axis the pubis is higher than it should be normally, while the sacrum is lower. The combination of lordosis with diminished pelvic obliquity is said to be

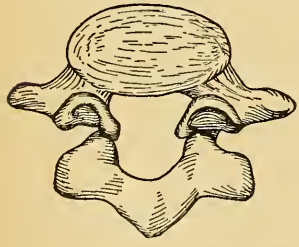

FIG. 162.—Specimen from the Museum of Kölliker at Wurzburg, Showing Double Defect of Vertebral Arch. (Neugebauer.)

pathognomonic by Neugebauer. The rotation of the pelvis is an important factor in that it tightens the anterior ligaments of the hip, and thus tends to cause a flexed position of the thighs.

Vaginal examination shows, of course, a prominence high up on the posterior wall of the pelvis. The trunk is shortened in relation to the legs on inspection, and the thorax tends to approach the pelvis. The gait in spondylolisthesis is said by Neugebauer to be modified. The affection is not one characterized by excessive pain.

The differential diagnosis must be made from Pott's disease, double

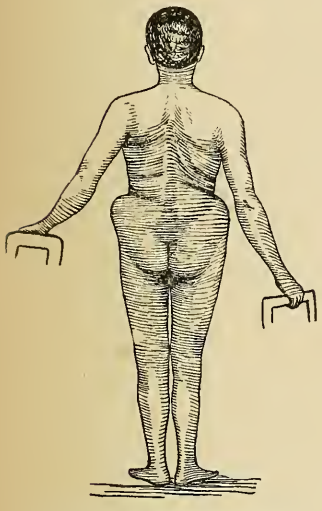

FIG. 163.—Case of Spondylolisthesis. Woman, thirty years old. (Breisky.)

FIG. 164.—Side View of Case of Spondylolisthesis. (Braun v. Fernwald.)

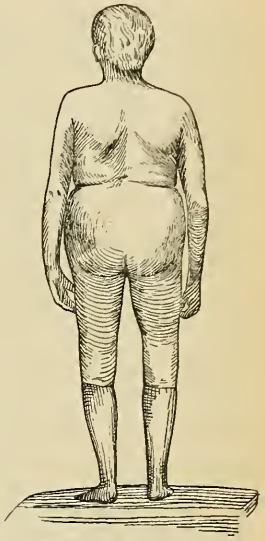

FIG. 165.—Back View of Same Case.

congenital dislocation of the hip, and rickets. Rickets must be recognized by its general diagnostic signs.

Treatment.—From the few cases considered, from a surgical aspect the most successful treatment consists in fixation of the lower spine by a jacket or brace until the fracture, if such has occurred, has united and the products of the injury have been absorbed; or, if heavy weight-bearing has been the cause, until the stretched and weakened tissues have resumed as normal a position as possible. This period must, of course, last for months, or in cases of great deformity it would seem as if a fixation support must be permanent. Laminectomy, as demonstrated by the case of Mr. Lane, is an operation to be considered when symptoms of bony pressure are present for any length of time. In Gibney's case an unsuccessful attempt was made to reduce the deformity under ether.

Recent Literature.

Lambl: Prager Vierteljahrschrift, 1856, 55–61; Cent. f. Gyn., 1881, No. 11, p. 251; No. 12, p. 281; 1885, No. 23, p. 356; Médecine russe, 1859, Nos. 11, 12, 16.

Krukenburg: Archiv f. Gyn., xxv., Heft 1.

Meyer: Archiv f. Gyn., xxxi., Heft 1.

Breslauer ärztl. Ztschft., 1882, 3 and 4.

Winckel: "Lehrbuch der Geburtshilfe," pp. 468–470.

Czaussouw: "Anat. top. du bassin," Warsaw, 1888, pp. 10–15 (in Russian).

W. A. Lane: Transactions of the Pathological Society of London, 1885, xxxvi., p. 364; Guy's Hospital Reports, xliii.; Lancet, 1893, xxix., p. 991.

Fig. 166.—Traumatic Spondylolisthesis in a Young Man of Eighteen.

Herrgott: Annales de Gyn., May, 1883.

Firnig: Woman, aged twenty-eight years; no history of fall. Berl. klin. Woch., 1887, xxiii., 509.

Hertzfeld: Woman, aged twenty-five years; fall in sixth year. Allg. med. Zeit., 1892, xxxvii.

Lane: Woman, aged thirty-five years; associated with progressive paraplegia. Laminectomy for relief of pressure of cauda equina. Lancet, 1893, xxix., p. 991; also April, 1892, No. 358.

Récamier: Man; between fourth and fifth lumbar vertebræ as a result of spondyloschisis; found in dissecting-room. Bull. de la Soc. d'Anat., 1888, p. 914.

Braun von Fernwald: One case, woman, aged thirty-six years; occurred under hard work. The most carefully recorded and illustrated of any case. Archiv f. Gyn., 1896, lii., p. 8.

Schleiser: Ein Fall von S. Becken. Inaugural Dissertation, Halle, 1890. There is said to have been a case reported by Herff. v. Braun, Cent. f. Gyn., 1891, xxviii., 603. No details. Woman.

Bohn: Woman, aged twenty-five years; fall when twenty-one years old. Inaugural Dissertation, Berlin, 1892.

Piskadek: Woman, aged thirty-nine years; probably ossification defect in fifth lumbar vertebra. Cent. f. Gyn., 1889, xlviii., p. 83.

Dollinger: Child, three years old, who fell backward in a room, and paralysis came on. Lordosis was marked, apparently, but the column could be felt to have fallen forward from the sacrum and could be pushed forward. Cent. f. Chir., 1891, xxiii., p. 457.

Bennett: Two preparations. Lancet, July 20th, 1889, p. 116.

Frank: Woman; no details. Cent. f. Gyn., 1892, xviii., p. 343.

Targett: Girl, sixteen years old; ordinary life; no hard work or trauma. Died of tetanus; specimen. Obstetrical Transactions, 1891.

Zoll: Traumatic case. Preparation of pelvis. Handbch. der gyn. Gesellsch. in Krakau, 1891, ii. p. 47.

Roth: Man, seventeen years old; fall in jumping; increasing deformity. Posterior spinal support with immediate relief. Chir. Society of London, 1891.

Chiari: Pelvis; forty-two-year-old person, with exostoses. Pelvis; thirty-two-year-old woman; fall at fourteen; and two other preparations. Zeitsch. f. Heilk., 1892.

Buchheister: Geschichte der Aet. der Sp. Inaugural Dissertation, Strassburg, 1894 (a review containing no new cases and nothing of especial interest).

Jellinghaus: Arch. f. Gyn., 1896, p. 428.

Vedeler: Norsk. Mag. f. Læg., Kristiania, 1896, 4 R., xi., p. 833.

Bieganski: Medycyna, 1890, No. 22 (en polonais).

Billroth: Archiv f. klin. Chirurgie, 1896, Bd. x., p. 42.

Blasius: Mon. f. Geb., 1868, Bd. xxxxi., pp. 241-248.

Leisrinck: Langenbeck's Archiv f. klin. Chirurgie, 1872, p. 63.

v. Thaden: Archiv f. klin. Chirurgie, Bd. xviii., p. 454.

Sprains of the vertebral column occur at times after falls. Stiffness and pain may reach a considerable degree and render the diagnosis from Pott's disease impossible for a time. In the cervical region wry-neck may be present from muscular spasm. The pain may be very severe. This condition of sprain may persist for months, and in neurasthenic persons may merge into the so-called hysterical spine.

Actinomycosis of the spine has been recorded with partial destruction of four vertebræ, abscess, and pressure symptoms. Death occurred in eighteen months.[1]

Echinococcus[2] cysts of the spine have also been observed.

Hysterical Spine.

This condition is also described under the names of irritable spine, sensitive spine, spinal irritation, a functional affection of the spine, weakness of the spine, neuromimesis, etc. The affection may occur spontaneously or most often as the result of some trauma, either mild or severe. It appears as a sensitive and painful condition of the spine, manifested by sensitiveness most often over the spinous processes of the vertebræ, pain in motion and manipulation; and in most of the cases is associated with a certain amount of general neurasthenia.

Pain and tenderness are frequently found at the base of the neck, between the shoulders, in the lower dorsal region, or at the end of the spine. This pain is usually subacute, it is aggravated by fatigue, and it may be accompanied by much hyperæsthesia, which is usually localized in a comparatively small area where there is a complaint of a burning sensation, while no curvature or projection can be seen on inspection of the back. In the extreme cases, patients are unable to bear any weight upon the spine in sitting or standing, and they present the symptoms that suggest a hyperæsthesia of the ligaments or of the fasciæ of the back muscles. Ordinarily the patients are able to go about freely, but suffer great pain,

[1] Henck: Münchener med. Wochensch., 1892, p. 512.

[2] Friedberg: Schmidt's Jahrb., 1897; Bruns' Beitr., xi., 1894.

especially when their attention is turned to the subject of themselves. In a few instances of the severest sort the back is held stiffly, and any conscious attempt at bending is avoided by the patient; but unconsciously, when the patient's attention is directed in another way, the back will be seen to move with comparative freedom.

FIG. 167.—Pectus Carinatum, Showing Flattening of the Sides of the Chest. (Stone.)

A gait which is very similar to that of Pott's disease may be present, and also rigidity of the back in rising or stooping. As in that affection continued standing and walking may cause pain, the patient is very sensitive to any jar and may be relieved from discomfort in the recumbent position.

A careful examination of the patient usually shows that the symp-

toms of stiffness are more from an apprehension of possible pain of movement than from the unconscious muscular spasm seen in the acute stages of early Pott's disease. Pain on movement, moreover, is usually much greater than is seen in early Pott's disease.

Unnatural attitudes may be assumed on account of the sensitiveness,

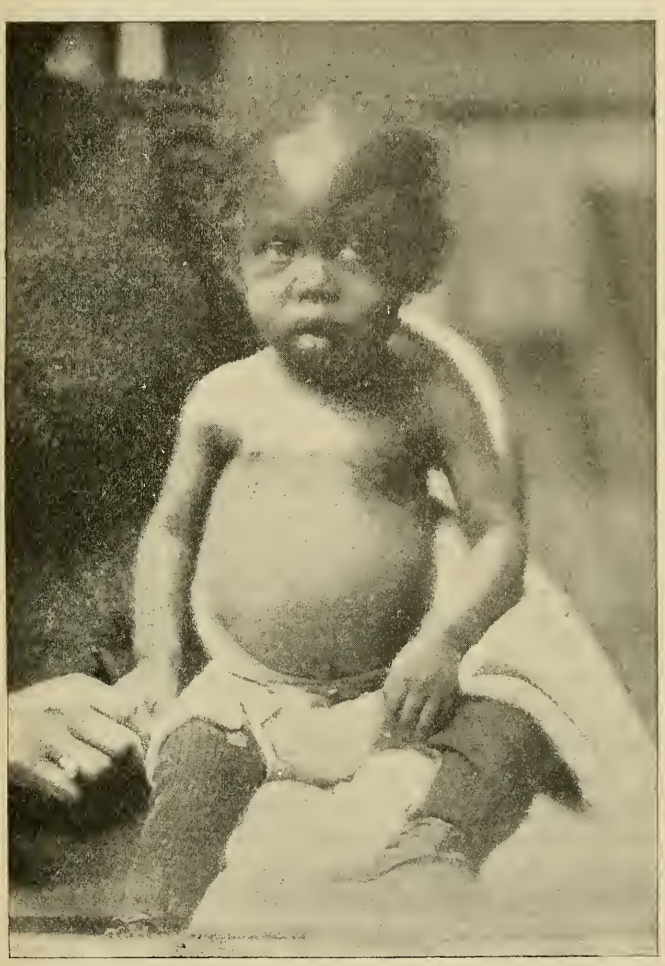

FIG. 168.—Harrison's Sulcus in Rickets. The lower border of the pleura and pericardium is marked. (Stone.)

such as a rounding out of the whole back in the dorsal region or a slight lateral deviation.

The spinal muscles and often the muscles in general are weak and flaccid.

The treatment consists in the improvement of the general condition

and in many cases in the use of measures usually indicated in neurasthenia. Rest to the back must be secured by recumbency for part of the

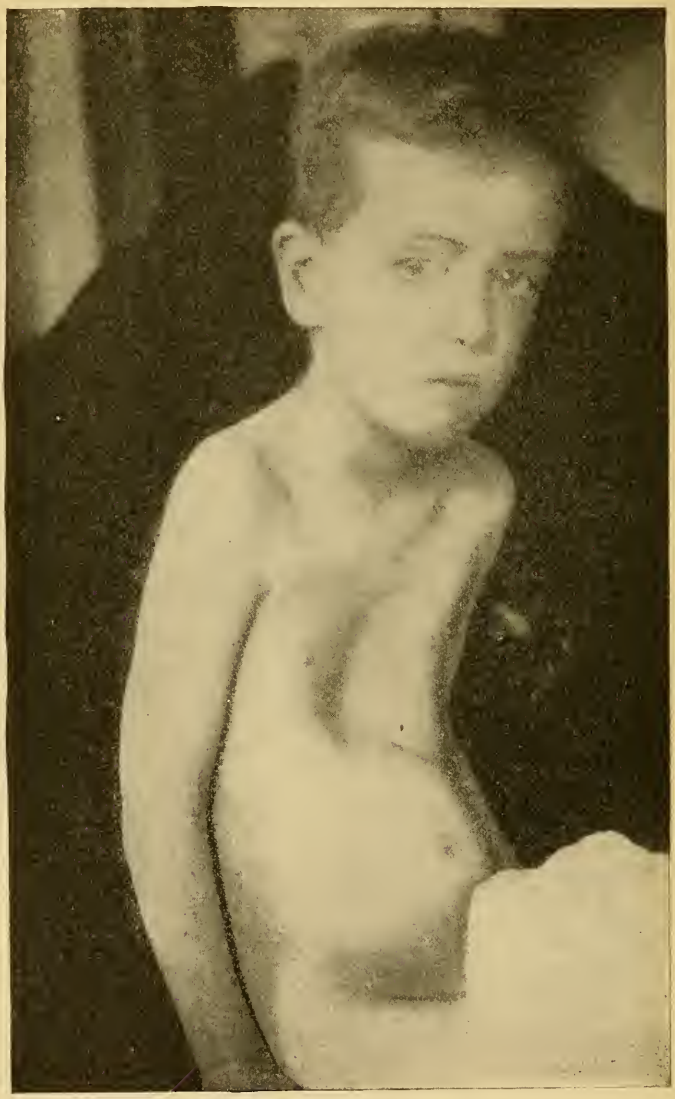

FIG. 169.—Funnel Chest. (Stone.)

day, followed by massage and exercises to strengthen the spinal muscles. The use of apparatus is sometimes indicated temporarily to enable the patients to assume the upright position in order that they may take exercise and get out of doors. In general the treatment of hysterical spine

does not differ from that of the treatment of functional affections of the joints.

Distortion of the Thorax.

A distorted condition of the chest may result as a secondary consequence of curves of the spine, or it may be congenital. The congenital deformities are rare. The sternum may be absent.

Pigeon breast (Hühnerbrust, Kahnbrust, pectus carinatum or gallinatum, poitrine en carène, poitrine de pigeon, etc.) is a deformity characterized by a prominence of the sternum and cartilages of the ribs. It occurs in young children more often than in adults and is most often due to rickets. It occurs also as the result of nasal or pharyngeal obstruction in growing children. It is seen often to an extreme degree in dorsal Pott's disease, in which it is due to the sinking forward of the upper dorsal spine carrying with it the ribs. Some unilateral prominence of the costal cartilages and anterior border of the ribs may result from scoliosis.

In severe rickets lateral flattening of the chest occurs, along with a transverse groove below the nipples, known as Harrison's sulcus; below this sulcus the lower part of the chest flares out.

Funnel chest (Trichterbrust, etc.) is the name applied to a depression of the sternum and costal cartilages the etiology of which is not always clear. It may occur to some extent in Pott's disease and in mild rickets, while in many cases it is not possible to assign a cause.

The deformities of the chest being as a rule secondary to other affections, their treatment is, of course, so far as possible, the removal of their cause. For the condition itself apparatus is of little use, but gymnastics may be of value.

CHAPTER IV.

THE PATHOLOGY, ETIOLOGY, AND COURSE OF CHRONIC JOINT DISEASE.

I. Joint diseases beginning in the synovial membrane: chronic serous synovitis, chronic purulent synovitis, chronic synovitis without effusion.—II. Joint diseases beginning in bone: tuberculosis, acute infectious osteomyelitis, tumors of the bones involving the joints, simple ostitis.—III. Joint diseases in constitutional affections: (1) syphilis; (2) arthritis deformans; (3) rheumatism; (4) gout; (5) acute infectious diseases; (6) gonorrhœa; (7) pathological conditions of the nervous system; (8) hæmophilia; (9) scurvy.—IV. Miscellaneous conditions: loose bodies, peri-articular abscess, growing pains, ankylosis, bursitis, etc.

The pathology of chronic joint disease is a subject the literature of which is very extensive, especially in this transition period; for no part of the pathological domain has experienced greater or more radical changes in the last few years, and to-day one has no accepted classification and no definite pathological system. A great deal has been written, but it has yet to be crystallized into some definite scheme.

No attempt will be made here to treat exhaustively the very extensive subject of the pathology of chronic joint disease, but simply to present it in its practical, surgical aspect, and in its very important clinical relations.

Most of the diseases of the joints may be considered under one of the two following headings. Other affections demand separate consideration.

I. Diseases beginning in the synovial membrane.

II. Diseases beginning in the bones.

I. Diseases Beginning in the Synovial Membrane.

Chronic synovitis appears as chronic serous synovitis, chronic purulent synovitis, or chronic synovitis without effusion.

Chronic serous synovitis is also known by the names of dropsy of the joint, hydrarthros, hydrarthrosis, hydrops articulorum chronicus, etc. As a rule, pathological changes are present in the synovial membrane of a character about to be described; but certain cases show no obvious pathological changes beyond increase of fluid for a long time.[1]

[1] Frierichs: Wagner, "Handwörterbuch der Phys.," iii., 1446; "Dict. de Méd.

The most common form of chronic serous synovitis is that which succeeds one attack or a series of attacks of a cutesynovitis, and here the pathological changes are evident, although they are at first very slight. One sees in the commencement only a slight increase of vascularity and a tendency to thickening of the membrane, which begins, perhaps, to look boggy from soaking in the excess of joint fluid. This fluid may be insignificant or very large in amount; it is ordinarily yellowish or colorless, but at times it is red from blood originally effused.

Increased vascularity and thickening of the membrane are followed by an hypertrophy of the synovial fringes. This hypertrophy varies from a slight and almost imperceptible hyperplasia to a condition in which the fringes are transformed into a mass of fibrous polypi, so that the synovial surface may be fairly shaggy. At other times the fringes are translucent, seeming to be (as they often are) fat enclosed in a delicate capsule.

Meantime, the subsynovial tissue has hypertrophied, and in some cases it is known to have increased to an inch in thickness, and if the fluid has been long in the joint the synovial membrane and the parts below it look light yellow, pulpy, and boggy. If the effusion has been extreme the capsule has either become enormously thickened or has become much distended. If so, the lateral and internal ligaments, weakened by the continual tension and soaked by the contained fluid, have also stretched, and lateral motion may be found in the knee-joint, even to the extent of 60°.

There may, however, have been, instead, a development of cysts in connection with the joint, practically herniæ. These occur oftenest in the popliteal space in connection with the knee-joint (Baker).[1] The view is advanced by Riese[2] that these cysts are rather the result of cystic degeneration of periarticular structures. This theory is based upon the obliteration of the blood-vessels.

The most common causes of chronic serous synovitis are traumatism, exposure to cold, rheumatism, the presence of loose bodies, etc.

The outcome of simple serous synovitis is in absorption or suppuration, or a persistence of the condition with a continually increasing disability of the joint.

One form of chronic synovitis is marked by such periodicity that it is spoken of as *intermittent hydrops*.[3] No changes may be found in such joints, although the affection may have existed at times for years. No

et de Chir. pratique," 8, 89; Bonnet: "Mal. des Artic.," Paris, 1845; Billroth: "Surg. Path.," 1883. Am. ed., p. 578; Arch. f. kl. Ch., ii., 408.

St. Barth. Reports, xiii.

[2] Cent. f. Chir., 1898, p. 585.

[3] Weisz: Berl. Klinik, 1898, No. 119. Senator: Charité Annalen, Bd. xxi; Seeligmüller: Deutsch. med. Wochensch., 1880, 51.

etiology has been determined and the disturbance is thought to be vasomotor in character. The time of appearance of successive attacks is remarkably regular, the interval being usually about a fortnight.

Chronic purulent synovitis, or, rather, purulent arthritis, aside from the tuberculous form (which will be considered in speaking of diseases originating in bone), may be consecutive to the infectious acute inflammations, or the infection may have extended from neighboring parts. The joint is in these cases filled with pus and the synovial membrane infiltrated and covered with a fibrinous deposit. The cartilage in cases of long standing becomes cloudy and fibrillated, and necrosis may occur in spots. If the process is continued long enough the ends of the bone become involved and carious abscesses are likely to occur. Recovery then takes place by the formation of cicatricial adhesions and the deposit of new bone.

FIG. 170.—Chronic Arthritis Following Wound. (Warren Museum.)

Chronic dry synovitis is found as a senile change, not always distinguishable from rheumatoid arthritis, as a neuropathic disorder, and as the result of the fixation of joints in one position. In Reyher's experiments, at the end of a year's fixation it was found that the cartilages of the joints had degenerated at the points where they were not in contact.[1] In such joints with a shortened capsule and thickened synovial membrane forcible manipulation may rupture the ligaments and produce hemorrhage from the synovial outgrowths.

In the "ulcerative" form there is a fibrillation and a disintegration of the articular cartilages. This is accompanied by thickening of the capsule and hypertrophy of the synovial folds and fringes. Lime salts may be deposited in the capsule and cartilage, and as the latter wears away the ends of the bone become eburnated and sclerotic.

Chronic dry synovitis also occurs in the form known as "ankylosing" (arthritis ankylopoetica). This may be the result of an acute exudative inflammation or as the final stage in chronic destructive processes. It occurs also in chronic rheumatism.

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[1] Menzel: Langenbeck's Archiv, xii.; Moll: "Unters. über d. anat. Zustand d. Gelenke bei andauernder Immobilization," Berlin, 1885; Reyher Deutsch Zeit. f. Ch., iii., 1873; Volkmann: "Hydrarthros," Berlin. klin. Wochensch., 1870.

II. Joint Diseases Beginning in Bone.

TUBERCULOSIS.

The modern view justifies the consideration of tuberculous joint disease under this heading. This class of affections has from time to time been described under the following names: Tuberculous ostitis or osteo-

Fig. 171.—Tumor Albus. Small focus in upper epiphyseal line of tibia. Synovitis of joint, but no tuberculous process apart from focus as noted. Death from miliary tuberculosis. *a*, Epiphysis; *b*, primary focus; *c*, shaft. (Nichols.)

myelitis, tuberculosis of joints, scrofulous or strumous joint disease, caries, fungous joint disease, gelatinous arthritis, white swelling.

It is called in German, scrofulöse Caries, tuberculöse Caries, scrofulöse Gelenkentzündung, and fungöse Arthritis, Gelenktuberculose, etc.

In Latin, Caries mollis sive fungosa, fungus articuli, caries sicca, etc.

French names aim at greater precision in speaking of ostéo-périostite tuberculose chronique, tuberculose articulaire, tubercule tardif à évolution rapide, and ostéite aiguë.

In whatever joint it appears it presents itself in much the same form, as an affection of the spongy tissue of the epiphysis, most often near its

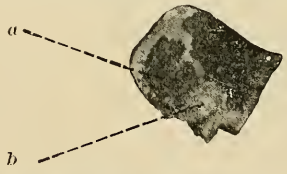

Fig. 172.—Hip Disease. Primary tuberculous focus in head of femur, near epiphyseal line. *a*, Head of femur; *b*, tuberculous focus in epiphyseal line. (Nichols.)

line of junction with the shaft; but sometimes near the articular cartilage, and rarely in the periosteum. It occurs mostly as a localized disease, appearing in one or more distinct foci; a simultaneous tuberculous

infiltration of the whole epiphysis (the infiltrated tubercle of Nélaton), however, rarely happens.

The common form of tuberculous infection of the epiphyses is the one spoken of as focal or encysted, when the first change is the formation of single or multiple foci of tuberculous degeneration. On section of the diseased epiphysis the first noticeable change consists in a local hyperæmia of some part of the spongy tissue. There then appears in this hyperæmic area a small grayish translucent spot almost as small as one can see, which grows more gray and increases in size, while a zone of hyperæmic tissue develops around it and the neighboring bone looks boggy from an excess of the transuded fluid. At first usually there is no synovitis, it is purely a localized ostitis.

FIG. 173.—Section of Tuberculous Synovial Membrane. (Nichols.)

Under the microscope the process appears to be as follows: The tubercle bacilli, being lodged in the marrow of the bone, cause a multiplication of the surrounding cells, probably by the action of a toxin, and a typical tubercle is formed. Such an area consists of a central mass of giant and epithelioid cells surrounded by a zone of lymphoid cells. As the tuberculous area increases by multiplication of the cells, the centre degenerates, forming a necrotic mass in which fat drops may be seen. Sometimes the tubercle bacillus can be found, usually in small numbers, in the giant

cells, or in the epithelioid cells, or between them. The process extends by the formation of other tubercles, apparently due to the multiplication of the tubercle bacilli and their diffusion through the tissues. New necrotic areas like the first are found which coalesce and form a mass of caseous material. Around the tuberculous area there appears a zone of non-tuberculous granulation tissue early in the process.

FIG. 174.—Edge of Tuberculous Focus in Bone. A portion of caseous marrow surrounded by necrotic bone trabeculæ. Outside this is an area of tubercles, and still farther from the centre is fat marrow with much œdematous fibrous tissue. (Nichols.)

During the later and reparative stages of the process this area becomes less vascular and is converted into denser fibrous tissue.

As the individual tubercles meet and coalesce they form in the marrow of the bone irregular caseous masses. In this way large areas of bone may be involved by peripheral enlargement of the tuberculous area. This area may soften and a tuberculous bone abscess may result, the purulent material containing bone fragments like sand.

Instead of forming a "bone abscess" the process may result in the formation of a sequestrum composed of necrotic trabeculæ retaining their shape and lying in a cavity in the bone. About the sequestrum is a

layer of granulation tissue. The sequestrum may take the shape of a wedge having its base toward the joint, in which case it is known as a "bone infarct."

As the diseased focus grows larger it looks more yellow in spots, and shows at its centre a tendency to cheesy degeneration, and later in the history of the affection one finds nodules, varying in size from that of a pea to a hazelnut, which are filled with a putty-like substance, such as

FIG. 175.—Perforation of Articular Cartilage from Bone Focus. Shows tubercle in bone marrow. Cartilage is somewhat fibrillated, and contains numerous irregular cavities filled with spindle-shaped cells. (Nichols.)

the cheesy material found elsewhere in the body, except that it contains spicules of bone from the trabeculæ, and in the larger foci pieces of dead bone of considerable size are found.

Later in the history of the affection the tuberculous nodule may break down into purulent material.[1]

Generally the original focus is surrounded by smaller tubercles which aid in its extension; but the chief work is done by the erosive action of the granulations, which take the place of the progressively rarefied bone.

From the stage of tuberculous infiltration the process may follow any one of three courses: the diseased focus may be absorbed and so cured; it may extend to the periphery of the bone, and break through the periosteum and empty itself there; or, lastly and probably most commonly, it may extend to the joint and infect that.

(1) The absorption of the diseased focus is theoretically possible up

[1] Vincent's article, Ashhurst's Encyclopædia, vol. vi., p. 908.

to a late stage in the process, so long as the disease remains strictly local and no sequestra of any size have formed; the pus may become cheesy and calcified.

(2) The next most favorable termination to the disease is when the focus does not infect the joint but breaks through the periosteum, and discharges into the peri-articular structure. This happens when the focus is so situated that the line of least resistance takes it to another part of the bony surface away from the joint, there forming probably an abscess which must be evacuated externally or break. Sometimes this ends the disease; the granulation tissue becomes fibrous, and then osseous, and

FIG. 176.—Spina Ventosa of Finger. Shows original shaft; marrow caseous or infiltrated with tubercles. Cartilage nearly normal. Periosteum thick and tuberculous. No periosteal new bone. (Nichols.)

the disease is over. This, according to Krause, is most likely when the focus is in the upper or lower end of the tibia or in the olecranon.[1] It is not likely to occur in the hip on account of the extensive distribution of the capsule.

(3) Probably the commonest course for this localized ostitis to pursue is to break into the joint cavity, and the ease with which infection of the joint from the epiphysis is produced will be readily understood by considering the pathological conditions.

The seat of the disease in the beginning is ordinarily not far from the cartilage. At first it excites no joint inflammation, but when it reaches a certain stage, even before it breaks into the joint, inflammatory reac-

[1] Krause: "Tub der K. und Gelenke," 1891.

tion in the joint begins.[1] The inflammation of the joint at first is non-tuberculous, the synovial membrane appearing thick and œdematous, the cavity of the joint being filled with a serous inflammatory exudate. This process may be very extensive, and Volkmann[2] claimed that obliteration of the joint cavity might occur from the cicatrization of the non-tuberculous inflammatory process.

Perforation of the joint by the tuberculous focus is the next step in the process. When the tuberculous focus underlies it, the cartilage of the joint begins to disintegrate and appears softened and yellow and finally breaks through. The perforation frequently occurs near ligaments. The tubercle bacilli, having entered the joint, are quickly disseminated by movement of the articulation, and the synovial membrane becomes infected.

The synovial membrane then appears thick, smooth, and shining and sometimes nodular, the surface is studded with small specks not larger than the head of a pin. The yellow tuberculous areas increase and soften, and tuberculous ulcers of the synovial membrane form. The thickened synovial membrane extends as a pannus growth over the edge of the articular cartilage, sometimes covering the whole cartilage. At the same time the tuberculous process may extend between the cartilage and bone. The cartilage beneath the pannus layer is destroyed and disintegrated while the free surface of the cartilage becomes fibrillated and ulcers appear in it also. When the tuberculous process extends beneath the cartilage the latter is eroded and destroyed.

Large areas of cartilage may be detached from the underlying bone, and sometimes the entire cartilage may be loosened as in the hip-joint. Under these conditions the denuded end of the bone is seen to be covered with nodular granulation tissue filled with tubercles, caseous and otherwise. As the disease goes on the cartilage is destroyed or cast off in sheets, and the denuded bones are attacked by the tuberculous process and are eroded. As a result of this, articular cavities are enlarged and distorted, and distortions and subluxations may occur. The tonic muscular contraction accompanying joint disease tends in certain joints to crowd together the softened ends of the bones and hasten the wearing away.

Microscopical examination of the diseased area at any time before all structure is lost shows a typical granulating tuberculosis. Within the low-grade granulation tissue one finds numerous and characteristic tubercles with epithelioid and giant cells (König), but with the increase of cheesy degeneration the typical tuberculous structure becomes more and more obscure.

Thickening of the capsule, infiltration of the peri-articular tissues, and

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[1] Lannelongue: "Coxo-tuberculose," Paris, 1886.

[2] Volkmann: Samml. klin. Vortr., No. 52.

thickening of the ends of the bones are clinical manifestations, and abscess formation and all the other complications are ready to follow.

About the affected joint is formed a layer of granulation tissue which may be converted into fibrous tissue. This process may be very extensive and accounts for such phenomena as the ovoid swelling in tumor albus and the thickening of the trochanter in hip disease. This fibrous tissue may be œdematous, and the spaces may contain a fluid reacting to stains like mucin.

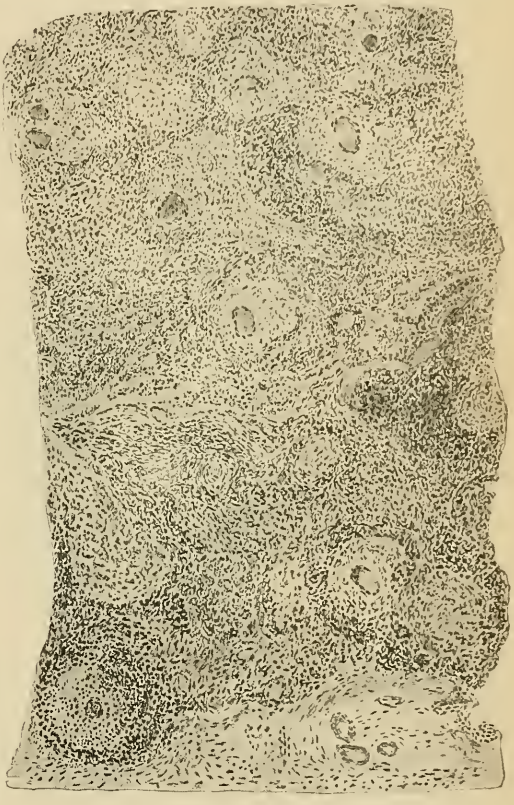

FIG. 177.—Section of Tuberculous Synovial Membrane. Numerous tubercles with giant cells. Between these, œdematous granulation tissue with many lymphoid and plasma cells. (Nichols.)

Repair is brought about by the formation of fibrous tissue, probably arising from the layer of non-tuberculous granulation tissue which grows into and replaces the tuberculous material. Caseous material is largely absorbed, and the inspissated remainder is replaced by fibrous tissue or is calcified and encapsulated. Fibrous, cartilaginous, or bony ankylosis may result from the process of repair.

It is most important to note that the process of repair may be incomplete, and that small areas of tuberculous material encapsulated by fibrous tissue may persist for a long time and under favorable conditions may become active and cause a recurrence of the disease. This fact must always be borne in mind in forcibly manipulating convalescent tuberculous joints.

Certain variations of this process must be described. Other types of synovial affection from that described are found at times.

Arborescent tuberculous synovitis is the name given to a condition in which the synovial membrane is covered with branching arborescent tags frequently coated with fibrin. These tags, which may be of considerable

size, consist of vascular connective tissue containing tubercles. Sometimes a large amount of fatty tissue may be present, constituting the "lipoma arborescens."

Solitary tuberculous nodules of the synovial membrane are described by König, Riedel, Krause, and Cheyne. Nodular and even polypoid growths with little tendency to caseation project into the joint. Although at first the rest of the synovial membrane is but little affected it becomes involved later.

Rice bodies are occasionally found free or pedunculated in tuberculous joints. They consist either of fibrin arranged in concentric layers or of vascular connective tissue.

Hydrops articulorum tuberculosus was a name given by König to a chronic effusion of joints said to be primarily synovial. In these there

FIG. 178.—Tuberculous Disease of Knee Excision. View, from above, of upper end of tibia. Shows large oval area of tuberculous softening. Clinical history not known. (Nichols.)

is said to be at first no marked thickening of the synovial membrane. Later the membrane assumes the typical character of tuberculous synovial inflammation. A similar condition of joints with a purulent effusion is described as "empyema tuberculosum."

It has always been asserted by writers on bone tuberculosis that primary disease of the synovial membrane occurred. Volkmann, however, as early as the writing of his classical monograph, said: "The fungous inflammations of the joints begin generally, and in children almost without exception, not at all as an arthropathy, but as a pure osteopathy, with a very circumscribed caseous or tuberculous ostitis."[1]

Nichols[2] in one hundred and twenty tuberculous joints examined from children and adults, many from excisions, a considerable number from

[1] Volkmann: Klin. Vortr., v., p. 1405.
[2] Nichols: Orth. Trans., vol. xi., p. 383.

autopsies or amputations, did not see a joint, in which, if all the bones entering into the joint were sawed open, one or more old bone foci were not found.

Krause admits that the more one makes it a rule to saw open the bones the less often will cases be considered primary disease of the synovial membrane. Complete examination of a joint at operation is usually difficult and oftenest impossible, so that conclusions as to the absence of primary bone disease based upon such examinations must be accepted with caution.

Although primary tuberculosis of the synovial membrane is described by those whose statements carry great weight, the results of Nichols' investigations must be borne in mind, which are positive and not negative conclusions.

The writers are of the opinion that primary disease of the synovial membrane is a diagnosis warranted only after all bones forming the joint have been sawed open in all parts. And that for clinical purposes, until the contrary is proved, one must assume that practically all tuberculous joint disease has its origin in bone.

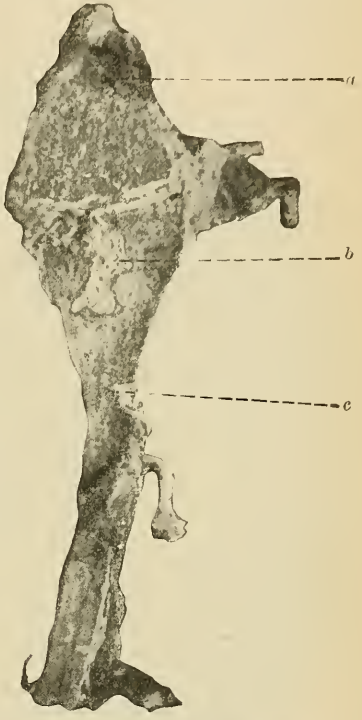

FIG. 179.—Fibula from Tumor Albus. Joint showed general tuberculous synovitis. No other foci. No apparent communication with the joint. *a*, Femur; *b*, tuberculous focus; *c*, fibula. (Nichols.)

Cold Abscesses of Joints.—If the tuberculous process in the bone reaches the surrounding tissues by perforation of the cortex and periosteum or by rupture of the joint capsule an abscess is likely to occur. The area of tuberculous softening in the peri-articular tissues is formed by the coalescence and caseation of tubercles. Surrounding the softened area is a layer of tuberculous tissue about which is another layer of œdematous and vascular granulation tissue. This process may extend until a large cavity has been formed.

The contents of these abscesses are composed of caseous material from the degeneration of the tubercles and exuded serum with necrotic pieces of bone. In the fluid are polymorphonuclear leucocytes, often taking up little or no stain on cover slips. Pyogenic organisms are absent unless present by secondary infection. The fluid may be like true pus; it may be so thick that it will hardly flow; it may be thin and

watery and contain coagula, or it may be red or brownish from hemorrhage.

Microscopically tubercle bacilli may be found in the abscess, but they are to be identified, even after prolonged search, in only about one-third of the cases, according to Krause. In such cases inoculation experiments must be relied upon to establish their presence.

The wall of these abscess cavities is composed of an inner layer of tuberculous tissue, outside of which is a layer of secondary inflammatory

FIG. 180.—Wall of Tuberculous Sinus. Numerous tuberculous areas surrounded by œdematous granulation tissue, in which are many lymphoid and plasma cells. (Nichols.)

tissue. The inner layer may be granular or necrotic and ulcerated. The abscess extends by peripheral enlargement in the line of least resistance. The walls of tuberculous sinuses consist of an inner layer of tuberculous tissue outside of which is a zone of œdematous granulation tissue.

This type of joint disease is considered tuberculous for the following reasons:

1. Tubercles can be identified microscopically in practically all cases. On this subject all modern writers agree.

2. The tubercle bacillus is often present. Müller believed that with care they could usually be found. Cheyne believes that with careful search they can always be found. Nichols suggests that the process of decalcification necessary in order to cut microscopic sections of bone interferes with the staining reaction of the bacillus. Bits of tuberculous lung were soaked in weak nitric acid, and after two days the bacilli stained faintly and in small numbers, and after four days no bacilli could be detected.

3. Inoculation of animals with tissue from bones and joints affected by this type of disease produces general tuberculosis.[1]

4. Experimental production of tuberculous joint disease in animals. Hüter[2] and Schüller[3] rendered animals tuberculous by inoculation and by injuring their joints produced typical joint tuberculosis. Müller[4] injected tuberculous pus into the nutrient artery of the tibia in kids and produced tuberculous disease in the epiphysis and sometimes in the shaft of the bone and in the joint. Watson Cheyne produced similar results by the injection of pure cultures of the tubercle bacillus. Krause injected pure cultures into the joints of animals and produced tuberculosis of the joints. He also confirmed Schüller's experiments as to joint injury in animals rendered tuberculous. Although the injured joints became tuberculous, fractured bones in these animals healed in every case without showing tuberculous infection. Triconi performed similar experiments.

5. The frequent association with phthisis, tuberculous meningitis, etc., of this type of joint disease helps to confirm its tuberculous character, if such confirmation were needed. Watson Cheyne reports that in 386 cases observed for three years 42, or 10.8 per cent, had contracted or succumbed to tuberculous meningitis of phthisis. In 2,106 cases of carious disease of bones and joints investigated by Billroth and Menzel from the post-mortem records at Vienna (1817–67) 52 per cent showed tuberculosis of the internal organs. In 837 resections of the hip Wartmann reports that 10 per cent of the patients died of generalized tuberculosis, which came on in such a way as to suggest that the operation was a causative factor.

Billroth found that 54 per cent of patients dying with this form of joint disease die of acute miliary tuberculosis; Jaffé, that 53 per cent of the deaths are from general tuberculous infection.[5] Grosch's extensive

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[1] Cheyne: British Med. Jour., April, 1891.

[2] Deutsch. Zeit. f. Ch., 1872, xi., 317.

[3] Schüller: "Exp. und histol. Untersuchungen," Stuttgart, 1880.

[4] Cent. f. Ch., 1886, No. 14.

[5] N. Y. Medical Journal, p. 325, 1884; Garré: Deutsch med. Woch., No. 34, 1886; Triconi: Baumgarten's Jahresbericht, ii., p. 229, 1886, quoted by Dennis, N. Y. Med. Assn. Rep., ii., p. 331, Grosch Cent. f. Chir., 228, 1882.

statistics show that in hip disease tuberculosis is, in spite of antiseptic precautions, the commonest cause of death. Nor does the removal of the diseased joint seem to diminish this liability very much. König[1] did 117 resections for this class of joint diseases, and of 25 deaths found 18 due to general tuberculosis, and 9 more patients hopelessly tuberculous.

Caumont[2] found no preventive effect in resection, for in 26 cases of hip disease, treated expectantly, one-fifth succumbed to generalized tuberculosis, while 12 others were resected and one-third of the patients died of the same cause.

6. Human beings are susceptible to tuberculous inoculation. Lehmann[3] relates the tuberculous infection of 10 children (fatal in 7) who were circumcised by a phthisical rabbi in a small continental town. The prepuce became the seat of tuberculous ulceration and the inguinal glands enlarged and suppurated. Similar cases are related by Elsenberg,[4] Mecklen, and Holst,[5] in which the presence of bacilli in the affected tissues was demonstrated.

A case related by Pfeiffer deserves especial mention. A veterinary surgeon of good antecedents and in sound health punctured the joint of his thumb with a knife, while dissecting a tuberculous cow; a synovitis of the tuberculous type followed, and he died in a year and a half of phthisis. His thumb joint showed typical tuberculous structures in which bacilli abounded.[6]

General miliary tuberculosis of bone occurs in connection with general miliary tuberculosis. The marrow is studded with miliary tubercles; necrosis and inflammatory reaction are slight or are absent.[7]

Etiology of Tuberculous Joint Disease.

Heredity.—That heredity is a factor in causing tuberculous joint disease has long been admitted. Whether the tuberculous virus can be directly transmitted as such from father or mother to the offspring must still be held open to question.[8]

Figures which attempt to show what proportion of children with joint disease inherit a tendency to these diseases are notoriously untrustworthy. In the class of hospital patients from whom most of these statistics come, anything approaching accurate information with regard to the diseases

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[1] König: Archiv f. klin. Chir., 26, p. 822.

[2] Caumont: Deutsch. Zeit. f. Chir., xx., 137; Yale: N. Y. Medical Journal, November 28th, 1885.

[3] Deutsch. med. Woch., 1886, 9–13.

[4] Cent. f. Chir., 1887, p. 52.

[5] Quoted by Barber Brit. Med. Jour., June 23d, 1888.

[6] Pfeiffer Fort. der Med., 1888, No. 1, p. 33.

[7] For further detail the reader is referred to the article of Nichols (Trans. Am. Orth. Assn., vol. xi.), which has been freely used by the writers.

[8] Quoted by Cheyne: "Tuberculous Disease of Joints," p. 97.

of which relatives have died cannot be expected. There is also an inclination on the part of parents to deny the existence of tuberculous disease in their parents and relatives. In this way parents of all classes are much more anxious to establish some traumatic cause for the affection of the joint than to have it supposed that the child inherited any constitutional taint. Again, it must be remembered that in a community in which approximately ten per cent of all deaths are from phthisis, phthisis must necessarily appear in the family histories of a certain proportion of any group of individuals whose antecedents are inquired into. For these reasons the following statistics cannot be regarded as other than inaccurate, and only approximating the truth, but the error is likely to lie always on one side, in making the proportion of inheritance too small.

Gibney[1] analyzed 596 cases of different tuberculous joint diseases, and found tuberculous disease in one or both parents in 68 per cent, and what he calls an "acquired diathesis" in 30 per cent more; and of the whole number, after a close investigation, he could find only 1 case which did not present an acquired or hereditary diathesis; but he represents an extreme point of view in the matter. C. Fayette Taylor,[2] in the analysis of 845 cases of Pott's disease, found 34 per cent in which there was tuberculous or so-called scrofulous disease in the parents, and in 66 per cent the disease came on in patients of a sickly diathesis. In 401 cases of hip disease from the Alexandra Hospital reports, 24 per cent had phthisis in the family history[3] and 35 per cent were classed as traumatic. Albrecht, tabulating 325 cases of tuberculous disease of various joints as to etiology, classed 33 per cent as "associated with scrofula." In 1,842 cases tabulated from Gibney, Taylor, and Croft 41 per cent were in children, one or both of whose parents had phthisis.[4]

Traumatism.—Experimentally it has been seen that trauma to the joint of a tuberculous animal may cause tuberculous joint disease, but that it does not do so in the healthy animal. It has been established that contusions and wrenches cause the effusion of blood in the spongy tissue of the bone. König has seen cases in which tubercles developed directly from the clot, just as in a syphilitic individual a gumma may develop at the site of an injury to the bone. "There are cases in which the swelling from the fall merges into the tuberculous swelling."[5] It would therefore seem rational to assume that trauma caused tuberculous joint disease in children who inherited a constitutional taint. But it becomes evident at once that this is not all, for every surgeon of experience must

[1] Gibney: "Strumous Element in Joint Disease," N. Y. Med. Jour., July, 1877.

[2] From preface of German translation of "The Mechanical Treatment of Pott's Disease."

[3] Croft: Clin. Soc. Transactions, London, vol. xiii.

[4] Nichols: Orth. Trans., xi., p. 358.

[5] König: Deutsch. Zeit. für Chir., 1879, xi.

have in his mind cases in which joint disease of a tuberculous type has followed injury in children whose family histories were exceptionally good.

König estimates half the cases as traumatic; Albrecht, one-sixth; Croft, 35 per cent; Gibney, 42 per cent (of which 72 per cent were also hereditary); C. F. Taylor, 53 per cent (in 845 cases). Gibney observed 845 cases of spinal paralysis (a class of children subject to constant falls and injuries), for several years, and found only four complicated with joint troubles. Roser observed 100 children at Marburg with fracture of the elbow, and in no case did tuberculous disease follow.

In certain cases traumatism alone must be accepted as the causative factor, while in some cases no cause can be assigned.

The exanthemata must be mentioned as being the cause of tuberculous joint disease in a certain proportion of cases, probably a larger proportion than has been suspected. Measles and scarlet fever are the most common eruptive diseases to be followed by these sequelæ. Croft estimates that about seven per cent of chronic tuberculous joint disease in children follows the exanthemata, but there are very few figures bearing upon the subject. The effect of the exanthemata in causing other forms of joint disease will be alluded to later.

The entrance of the bacilli is apparently most often through the respiratory and digestive tracts.

It is probable that whatever continuously diminishes the power of resistance and of repair in growing children increases what may be termed the vulnerability of the epiphyses, and furnishes the soil for the development of tubercle bacilli and the consequent results.

Age.—Tuberculous joint disease is pre-eminently a disease of childhood. It is rarely, if ever, congenital,[1] and under one year it is not common. Of Gibney's 860 cases, so often alluded to, 84.5 per cent of all cases occured before fourteen. Of 619 cases of hip disease tabulated by Mr. Wright,[2] there were under ten years 150 cases; under fifteen years, 279.

Bryant tabulated 360 cases, finding 223 cases under the age of ten.

Taking Wright's and Bryant's cases, and adding 365 others reported by Sayre,[3] there are 1,344 cases of hip disease, of which 1,000 occurred under fifteen years of age.

This is natural enough, for tuberculous disease affects chiefly the epiphysis, and the epiphysis during its period of greatest activity when its blood supply is largest and its tissue changes are most rapid. Moreover, children are especially subject to falls and are not so easily kept quiet as adults are after injuries.

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[1] N. M. Shaffer: "Am. Clin. Lectures," vol. iii., 141; Sonnenberg: Arch. f. klin. Chir., 1881, xxvi., 789; Lannelongue: Loc. cit.

[2] "Hip Disease in Childhood," p. 2.

[3] L. A. Sayre. "Orthopedic Surgery and Diseases of Joints."

The records of the New York Orthopedic Dispensary show the liability at different ages in the cases of joint diseases of the lower extremity treated for the years 1884–86:

	Under 3.	3 to 5.	5 to 10.	10 to 15.	15 to 20.	Over 20.
Hip	115	316	509	140	47	51
Knee	43	69	94	28	22	63
Ankle	12	18	24	18	4	7
Total	170	403	627	186	73	121

But such statistics, as Cheyne points out, are not altogether reliable. More people are alive at the age of five years than at any later age, so that the tendency of such statistics, if uncorrected, is to exaggerate the frequency of joint tuberculosis in young children. In various continental cities investigations as to the relative frequency of phthisis at different ages have shown that in later life a relatively greater proportion of persons die of phthisis than at the period (from fifteen to thirty years) when it has been supposed to be most frequent. If the frequency of joint tuberculosis at different ages is investigated, employing the statistics of persons alive at different ages, the result is as shown in the table of Cheyne and Fassbender.

Age.	Apparent frequency, ratio per 1,000 of population.	Real frequency, ratio per 1,000 of population. (Cheyne.)	Real frequency, ratio per 1,000 of population. (Fassbender.)
1 to 5	232	167	108
6 " 10	153	134	145
11 " 15	150	145	113
16 " 20	153	164	157
21 " 25	85	98	77
26 " 30	88	120	109
31 " 35	41	60	76
36 " 40	30	48	106
41 " 45	20	36	66
46 " 50	20	42	85
50 " 60	14	17	About 60
60 " 70	0	0	" 42
70 " 80	7	33	" 21

The liability of the aged to tuberculous joint disease must not be overlooked. The fact that people over sixty are more often "scrofulous" than people between thirty and fifty is noted by Sir James Paget.[1]

The patients may be seventy-five or ninety, and cases of hip disease present the same pathological appearances here as in young children. The course of the disease is more rapid and destructive than in the young, and its etiological relations are decidedly more obscure.

[1] "Clinical Lectures and Essays. Senile Scrofula." 2d ed., p. 345.

The reasons given why tuberculous joint disease affects children to so great an extent are as follows:

In the active period of growth more change is going on and therefore more instability exists and consequently greater liability to disease. Children are more liable to falls and injuries, which are such a fertile source of joint and bone lesions. It is not till after puberty that the process of natural selection has eliminated the weaklings from the stock. Children are kept quiet less easily than adults, and a slight injury may develop into a formidable disease. Tuberculosis in general is common in childhood.

Sex is not a factor of any prominence, but there is a slightly larger proportion of tuberculous joint disease among boys than among girls. Of 619 cases of hip disease collected by Wright, there were 371 males. Holt,[1] in 2,307 cases of hip disease found 1,178 males and 1,129 females, but the preponderance is very slight. Cheyne in 386 patients found 65 per cent of males and 35 per cent of females.

Distribution of Chronic Tuberculous Joint Disease.—The relative frequency with which tuberculosis attacks the various joints may be estimated from the following figures:

At the Children's Hospital, from 1869 to 1893, 3,820 cases of tuberculosis of the joints were distributed as follows: Vertebræ, 1,964; hip, 1,402; ankle, 300; knee, 104; wrist, 20; shoulder, 15; elbow, 15. These practically all occurred in children under the age of twelve.

In 211 cases of joint tuberculosis among the out-patients occurring in children under two years there were 120 cases of Pott's disease, 61 of hip disease, and 29 of tuberculosis of the knee-joint:[2]

	Gibney, 614 cases mostly in children.	N. Y. Orthopedic Dispensary.	Cheyne, cases under 10 years.
Spine	209	1,024	78
Hip	271	1,178	44
Knee	103	319	24
Ankle	31	83	4
Shoulder		11	2
Elbow		11	13
Wrist		7	2

Cheyne added 601 cases of tuberculous joint disease of his own to those of Jaffé, Schmalfuss, Billroth, and Menzel, and found the relative percentage to be as follows: Spine, 23.2 per cent; hip, 14.6 per cent; knee, 16.5 per cent; tarsus and ankle, 14.4 per cent; shoulder, 1.5 per cent; elbow, 6.3 per cent; wrist and hand, 6 per cent.

It will be seen that although the figures from American sources agree fairly well with each other, those from European sources show a differ-

[1] Gibney: Loc. cit., p. 206. [2] Thorndike: Orth. Trans., ix., p. 196.

ence in the relative frequency with which joints are affected, possibly because more adult cases are included in the latter.

Judson[1] has called attention to the great preponderance of joint disease in the lower extremity as contrasted with the upper limb. Analyzing the reports of two orthopedic institutions in New York City he finds that in a single year the following number of cases of disease of the different joints were treated:

Hip-joint disease	577
Knee-joint disease	181
Shoulder disease	6
Elbow disease	8

or 758 patients had disease of the joints of the lower extremity, while in the same time there appeared only 14 cases of joint disease in the upper extremity.

In joint disease, when one or more articulations are involved, any combination may be found; but the most common are hip disease and Pott's disease, knee disease and Pott's disease, and double hip disease. Disease of both the knee- and hip-joints is not common, and double tumor albus is unusual.

Acute Infectious Osteomyelitis.

This is a process attacking the marrow of the bones, and secondarily affecting the joints if the process reaches or originates in the end of the bone rather than in the shaft. It is probably the cause of many, if not most, cases described under the name of "acute arthritis of infants." Acute osteomyelitis is a distinctly infectious process, sometimes limited to the marrow and sometimes involving the entire structure of the bone including the periosteum. Its onset is sudden, its manifestations are severe. Traumatism must be recognized as one exciting cause.[2] The disease belongs to the group of septic pyæmias (Ziegler).

The bacteria most frequently found are staphylococci and streptococci, alone or in combination. Other bacteria occurring are those of pneumonia and typhoid, and the colon bacillus.

In 71 cases of the "acute arthritis of infants due to osteomyelitis," described by Townsend, 20 were less than four weeks old, 10 were less than eight weeks, and 6 were in their third month. In 27 cases analyzed by Howard Marsh the hip was attacked 14 times, the knee 11, the shoulder 5, the ankle 4, the elbow 4, and the wrist once. Of the 27 cases 20 were monarticular.

Osteomyelitis begins as a hyperæmia of the bone marrow with possibly hemorrhagic infiltration. Later suppurative foci of a dull yellow

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[1] N. Y. Med. Record, May 18th, 1889. [2] Gebele: Inaug. Diss., Munich, 1897.

or grayish color appear, while in severe cases the entire marrow becomes purulent, and the Haversian canals of the cortical portion become filled with pus. There are cases in which infection occurs, but absorption takes place before the occurrence of suppuration. Metastatic abscesses and thrombosis of the veins of the marrow may follow.

If the inflammation reaches the epiphyseal cartilage in young patients separation of the epiphysis is likely to occur. In the hip-joint this leads to a lax condition of the joint, simulating congenital dislocation of the hip.

Metastatic inflammation of bone,[1] which may occur in pyæmia, typhoid, scarlet fever, and measles, may follow a clinical course similar to that described above. Usually the foci are smaller and destruction is less extensive.

If the infecting process enters the joint the inflammatory process becomes severe and destructive, cartilage is softened and destroyed, and an abscess of rapid appearance is the usual clinical manifestation.

Osteomyelitis may, however, be the cause not only of a suppurative but of a simple joint inflammation at times, due to the contiguity of the bone inflammation.[2]

In acute osteomyelitis the clinical symptoms are those of a very severe constitutional disturbance attended with high fever, chills, severe pain, and rapid exhaustion.

The prognosis depends in large measure on early operative interference. Ankylosis is likely to result from the process, as are also dislocations, subluxations, and distortion when the joints are involved. Epiphyseal separation must be watched for throughout.

The entrance of the organisms in young infants is probably through the umbilicus or pharynx. In older persons the germs probably enter through some abrasion or by the pharynx, tonsils, or alimentary canal.

Free incision, washing, and drainage at the earliest possible period is the only treatment to be considered.[3]

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[1] Swoboda: Wien. klin. Woch., 1897.

[2] Garré: Bruns' Beit. z. klin. Chir., xi., 1894, 797.

[3] Rovsing: Langenbeck's Archiv, Bd. liii., Heft 3; Herzog: Münch. med. Wochen., 1898, No. 14, 416; Still: Clin. Jour., 1898, 388; Griffiths: Jour. Path. and Bact., 1896–97, 327; Eve: Clin. Jour., 1897, x., 385; Kasparek: Baumgarten's Jahresber., 1895; Braquehaye: Gaz. de Méd. et de Chir., 1895, p. 199; Smith: St. Barth. Rep., 1874; Baker: Lancet, 1880; Wright: Lancet, 1881, July 23d, 127; Krause: Arch. f. klin. Chir., 1889, 477; Battle: Trans. Path. Soc., London, 1891; Gerard Marchant: Bull. Soc. Anat., Février, 1889, p. 151; Alibert: Gaz. hebd. de Méd. et de Chir., 1894, p. 254; Lannelongue et Achard: Ann. Inst. Pasteur, 1891; Koplik and Van Arsdale: Am. Jour. Med. Sciences, 1892; Mauclaire: Des Arth. suppurées dans les Mal. infect., Arch. gén. de Méd., 1895, January; Dardenne: Th. de Toulouse. 1894.

Simple Ostitis.

Simple or traumatic ostitis secondarily affecting the joints is very unusual. In the traumatic form, one finds blood effused and inflammatory processes beginning, of the kind described above as typical, the periosteum is infiltrated, and the bone marrow filled with a fluid cellular exudation. Then it depends upon circumstances whether absorption will take place or whether pus formation will begin, and the trabeculæ will be absorbed and the bone broken down, or whether the whole affair will take on the tuberculous type and run the course of that affection. If no infection comes, wounds, tears of the joint capsule, fractures, etc., result in only a serous or fibrinous or bloody effusion into bone, joint, and capsule; but when the bone is infected, suppuration and destruction may occur.

Tumors of the Bones Involving the Joints.

Primary tumors of bone belong to the group of connective-tissue tumors. The periosteum and bone marrow form the matrix for their development. These tumors correspond to the various types of connective tissue, fibrous, mucoid, cartilaginous and osseous. Among primary tumors are to be classed sarcomata. Secondary tumors of any kind may occur, among the latter being carcinoma. Angioma, hæmatoma, echinococcus cyst, and aneurism must be mentioned as other possibilities.

Exostoses.—Apart from the changes of arthritis deformans there sometimes occur exostoses about the articular ends of the bones, which are very rarely large enough to impede the motion of the joints; at other times they are troublesome by involving tendons in their growth.

They are of two kinds. First, small spur-like processes or rounded projections, the result either of an inflammatory process or of a simple hypertrophy; and several large lobulated, spongy masses of bone called diffused osteoid tumors, which occasionally involve and destroy a joint, as in the cases of Paget and Lancereaux, in which the knee-joint was so badly involved by the growth of one of these osteoid tumors from the tibia and femur that amputation was necessary.

Cartilaginous exostoses in the neighborhood of the joints have occasionally a capsule overlying the layer of cartilage corresponding in structure to synovial membrane. This condition is spoken of as a bursate exostosis (Ziegler).

Chondromata grow most frequently from the bones of the hand. They are often multiple, occur most often in children and young adults, and may be congenital. Myxomata and lipomata are rare in the bones.

Sarcomata originate in the marrow or periosteum. If they contain

bony tissue they are spoken of as osteosarcomata. Joint sarcomata affect chiefly young subjects from fifteen to twenty-five years old, and the joints commonly affected are the knee, shoulder, and wrist. Of 70 cases of giant-celled sarcoma analyzed by Gross 21 were in the femur (17 in the lower epiphysis), and 28 in the upper epiphysis of the tibia and fibula. Central sarcomata are more likely to invade joints than are the periosteal growths. Males are slightly more liable than females to be affected, 87 out of 149 cases being in men.

Carcinoma of bone may occur secondarily from extension or metastasis. It occurs in circumscribed nodes or as a diffuse infiltration. The latter is usually accompanied by proliferation of the periosteum and absorption of the substance of the bone. This is at times replaced by soft new bone, and a condition may be present resembling locally osteomalacia and known as carcinomatous osteomalacia.

With this form as with primary new growths spontaneous fracture may occur.

III. Joint Diseases in Constitutional Affections.

Certain constitutional affections are attended by joint manifestations. The remaining affections of the joints will be considered under etiological rather than pathological headings.

The principal affections accompanied by joint manifestations are:

I. Syphilis.
II. Arthritis deformans.
III. Rheumatism.
IV. Gout.
V. Acute infectious diseases.
VI. Gonorrhœa.
VII. Pathological conditions of the nervous system.
VIII. Hæmophilia, scurvy, etc.

I. Syphilis.

Acquired syphilis has certain joint manifestations.

Arthralgia without objective symptoms may occur early in the secondary stage.

Simple serous synovitis, associated with pain, redness, and swelling, may accompany the secondary symptoms. This condition may pass on to a chronic hydrops.

In the tertiary stage chronic serous synovitis may be present. It is slow in progress, generally accompanied by considerable effusion and much thickening of the capsule which may later contract and cause fibrous ankylosis. This thickening of the capsule may be due to a

chronic hyperplastic inflammation of the capsule (Finger) or to a gummatous infiltration of the subsynovial tissue (Richet, Lanceraux). There is generally a development of the tufts in the severer cases along with some destruction of cartilage, and perhaps the formation of osteophytes.

These and other processes may be the result of gummata of the ends of the bones or in the periosteum or situated about the joints, not necessarily in any intimate connection.

Gummatous ostitis is a cause of secondary affections of the joints when situated in their neighborhood. On section the bone shows, most often in the periphery, a yellowish-gray focus of disease, in appearance strikingly like the early stage of focal tuberculosis. But from this latter it may be distinguished by the absence of any surrounding hyperæmia or infiltration, which goes with tuberculous disease. Often, of course, these gummata exist along with much synovitis of a characteristic type, and a much thickened and diseased periosteum. Gummata in the periosteum appear as elastic swellings, rich in fluid, poor in cell elements; later they degenerate to material like pus and by fatty degeneration and absorption to a cheese-like substance and scar-tissue, and finally only a thickening remains.

Secondarily to these periosteal and bone lesions come the capsular and synovial thickening, and the cartilage degeneration.

Jullien has estimated that 28 per cent of all cases of tertiary syphilis develop bone lesions, while Gottheil in 248 cases of tertiary syphilis found only 13 cases of bone disease.[1]

Hereditary syphilis is proportionately more often attended by joint complications than is acquired syphilis.

Güterbock[2] estimates that arthritis occurs in one case in three hundred of hereditary syphilis in children under five years. Arthralgia is rare and acute synovitis is rare (Pielicke[3]) or absent (Kirmisson and Jacobson[4]).

Chronic serous synovitis has been described by Clutton, although such cases may be due to bone lesions (Fournier). The type described by Clutton occurs in children from eight to fifteen years as a symmetrical swelling of the knees accompanied by little pain or limitation or motion. The capsule may be thickened, and the effusion is generally moderate in amount.

The most characteristic form of joint disease in hereditary syphilis in children is the *osteochondritis* of Parrot. This consists in a broadening of the cartilaginous layer of the epiphysis next to the diaphysis with irregularity of the zone of ossification. At the same time there occur thickening of the epiphysis and a growth of granulation tissue, sometimes breaking down in the medullary cavity. As a result of this process separation of the epiphysis may occur spontaneously or as the result of

[1] N. Y. Med. Jour., February 4th, 1899. [2] Berl. klin. Wochenschr., 1884, 442.
[3] Lancet, 1886, i., 391. [4] Deutsch. Chir., Lief. 66, p. 294.

some trauma. Secondary synovitis is likely to accompany this process. This may be of any character and is often purulent, and the cartilage may degenerate and soften. Suppuration in general is less rare in hereditary than in acquired syphilis.

The clinical symptoms of this osteochondritis are thickening of bone, tenderness, and joint inflammation, secondarily with lameness and even uselessness of the limb for a time. The affection is sometimes spoken of as syphilitic pseudoparalysis of infants.

Later hereditary syphilis may show a somewhat similar affection due to overgrowth of the epiphysis, and spoken of as "chronic osteo-arthropathy of hereditary syphilis" or "false tumor albus." The thickened and deformed epiphyses form a mass which appears as a spindle-shaped swelling (most often at the knee). There is typically no muscular spasm, although marked atrophy of the muscles is present. Pain is generally absent, although rarely there may be some tenderness and local heat. What inflammation of the joint is present is secondary and not characteristic. It is favorably affected by the usual treatment for syphilis.[1]

II. Arthritis Deformans.

This affection is known by a multiplicity of names, of which the following are the principal ones: Rheumatic gout, chronic rheumatic arthritis, arthrite sèche, arthritis deformans, osteo-arthritis, nodosity of the joints, rheumatoid arthritis, nodular rheumatism, dry arthritis, proliferating arthritis, malum senile, chronic articular rheumatism. The name arthritis deformans will be adopted here, inasmuch as it describes the condition and involves no etiological theory.

The process is characterized by a hyperplastic proliferation along with degenerative changes in cartilage and bones.

Extensive softening of the cartilage occurs along with the formation of cavities in the deeper layer next to the bone. These cavities are later lined with vascular medullary tissue from the bone. The cartilage between these cavities is generally converted into osteoid tissue and bone.

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[1] White and Martin: "Genito-Urin. and Ven. Diseases;" Kirmisson and Jacobson: Rev. d'Orth., November, 1897, p. 446; Sonnenburg: Berl. klin. Wochenschr., 1884, S. 548; Finger: "Syph. u. d. vener. Krankh.," 1896, S. 114; Taylor: "Vener. Diseases;" Renard: Rev. d'Orth., 1893, No. 3, p. 187, Bosher: "Am. Text-book Gen. Urin. Diseases, Syph., and Dis. of Skin," p. 661; Danlos: Ann. d. Derm. et de Syphilig., 1896, vii., 1322; Anderson: Glasgow Med. Jour., 1896, xlvi., p. 9; Schüller: Beilage z. Centralbl. f. Chir., 1882, p. 31; *ibid.*, p. 32; Pielicke: Berl. klin. Wochenschr., 1898, p. 78; Baginsky: Berl. klin. Wochenschr., 1894, 548; Henoch: Berl. klin. Wochenschr., 1884, 548; Hirschberg: *Ibid.*, 548; Landerer: Berl. klin. Wochenschr., 1884, 757; Virchow: Berl. klin. Wochenschr., 1884, 534.

The changes in the cartilage are of the usual type of cartilage inflammation, only more severe. The hyaline substance becomes fibrillated, and where there is pressure it is worn away in small patches or large surfaces, exposing the bony lamella.

The changes in the bones are in the first instance the result of the wearing away of the cartilage covering the ends. This irritation results in hyperæmia which is attended by a slight degree of rarefying ostitis.

After the enlargement of the Haversian canals and the degeneration of the bone cells, a formative activity springs up in the periosteum and in the endosteum covering the cancellous walls, and a compact, "eburnated" layer is quickly made which covers the exposed end, under which layer a formative activity is going on while the polished surface is always being worn away; and to this constant wearing away is due the "worm-eaten" appearance so generally spoken of, which is due to the exposing of the ends of the Haversian canals.

The subchondral marrow frequently loses much of its fat and cysts may form in it, which may be exposed if the overlying bone is worn away.

But while pressure and friction are wearing away the centre of the articular ends of the bones, the margins are rapidly proliferating. The same process of cartilage degeneration taking place at the periphery of the joints results differently. There is sufficient freedom from pressure not to wear away the degenerated substance, and the edge of the synovial membrane retains the proliferated corpuscle cells, which remain, and, taking on a formative activity, make the marginal hypertrophies or ecchondroses. The hypertrophic bony enlargement is closely bound up with the development and increase of these marginal ecchondroses. These lumps internally are bony, superficially they are cartilaginous. Sometimes these perforate the synovial membrane and become intra-articular, and often break off to form loose bodies; at other times they grow laterally, and do not encroach upon the joint, but form a buttress-like growth which speedily restricts the motion of the joint, although true ankylosis rarely or never takes place, the stiffness and loss of joint movement being due to this ensheathing bony growth. Inasmuch as these ultimately ossify, an explanation of the extreme changes in the shape of the ends of the bones is afforded.

Finally, at the attached border of the capsule as well as in the ligaments themselves, there begins a dense bone formation which contributes to the ensheathing bony mass. The osteophytes are more rounded and flat than one is accustomed to see in bone formation after fractures, for instance; and from the fact that ossification is not preceded by any especial vascularity, the new-formed bone is more dense and compact than normal; the tissues ossify just as they are.

The wearing away of the articular surface of the bones may lead to

distortion of the joints. The head of the femur may completely disappear, and if new bone forms around the periphery an entirely new head may be formed which is attached to the shaft by little or no neck.

There is a thickening of the synovial membrane, a hypertrophy of the fringes, and finally the development of shaggy surface.

Synovial folds and villous fringes may increase until they fill the joint cavity. When fat is deposited in these the condition known as "arborescent lipoma" exists.

Thickening of the capsule and degeneration of the ligaments may occur; the latter become inflamed and then thickened, and finally they degenerate into a condition in which they resemble fibrocartilage or elastic tissue, and in virtue of this, the affected joints may show decided lateral mobility. The tendons and intracapsular ligaments may disappear by "absorption." Tendons may be found adherent to the bone with a part of their substance wanting. The muscles controlling the joint atrophy from disease as well as disuse.

Arthritis deformans is, clinically, a distinct type, though some cases are hard to separate from rheumatism. The most usual form met with is the chronic polyarticular. This attacks patients most often toward middle life, but it may occur in children or in later life. Females are oftener attacked than males. The etiology is still uncertain, but the neuropathic theory suggested by Mitchell finds many adherents. Ord goes so far as to assume a cord lesion. The usually accepted causation by damp and cold is at least doubtful, while the older theory accusing gout and rheumatism hardly finds adherents to-day. Here, as in many other conditions, bacterial action has been assumed.

Schüller[1] described a bacillus occurring in the joints of this affection with relative regularity. It grows on ordinary media. Injected into the joints of rabbits it produced no pus but remained in the joints, and two months after injection caused a process similar to that of arthritis deformans in man. The writers have not been able to find that this has been confirmed by other observers.

Dor,[2] by the injection of an attenuated culture of staphylococcus into the joints of rabbits, produced, after one year, joint changes similar to those of arthritis deformans.

Bannatyne described a small bipolar-staining bacillus existing in the fluid of these joints, and Blaxall[3] confirmed his observations. The articles of these two writers are not convincing, and one competent observer following Blaxall's technique with great care was unable to find any such microorganisms.

Heredity seems to play some part in the causation.

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[1] Berl. klin. Wochschr., 1893, p. 865.

[2] Comptes Rend. Soc. de Biol., 1893, p. 899.

[3] Lancet, 1896, i., p. 1120.

The monarticular forms are often consequent on some trauma and usually occur in older persons. The best known variety is the malum coxæ senile. This type differs from the polyarticular forms only in its local limitation.

In young children the clinical type differs somewhat, as pointed out by Still. This type appears before the second dentition. It may be acute in onset, and females are more often affected than males. There is some effusion, the capsule is thickened, there are degenerative changes in the cartilage, but no lipping or osteophytes. There are no subcutaneous "rheumatic" nodules. The affection is polyarticular. There is usually some enlargement of glands and spleen. The epiphyses may be hypertrophied.

Apart from this, arthritis deformans of just the type seen in adults may, and not infrequently does, occur in children—in this form, according to Still, usually after six years of age.

Morrant Baker[1] describes a considerable series of cysts secondary to rheumatoid arthritis and some cases with fluid free without obvious synovial sac wall.[2]

III. Rheumatism.

Rheumatism is an affection which receives credit for the causation of much joint disease with which it has really nothing to do. The manifestations of arthritis deformans are confused with the truly rheumatic affections, and as in simple acute synovitis of the knee in which no cause is assignable, the disposition of many practitioners is to consider the affection as "rheumatic," so in joint disease in general obscure cases are liable to be placed in this class.

In true rheumatic joint affections the structure attacked is chiefly the synovial membrane, which secretes much fluid and takes on a proliferative action with enlargement of the synovial tufts, a condition which may give rise to swelling of a joint without necessarily the presence of much effusion. The capsule becomes thickened, and although even in prolonged cases the cartilage is likely to remain intact, it may become fibrillated at the edges and eroded in spots, while a vascular pannus spreads in from the edges. The whole tendency is away from suppuration and toward connective-tissue formation. One form, which Schüller calls *arthritis rheumatica ankylopoetica*, shows but little or no effusion, but a tendency to the formation of fibrous, and later bony, ankylosis. This

[1] St. Barth. Hosp. Rep., vols. xiii. and xxi.

[2] "Arthr. Deform. in Children;" Tschernow: Cbl. f. Chir. (ref.). 1898, 853; Still: Clin. Jour., 1898, 388; Osler: Montreal Med. Jour., 1895–96, xxiv., 777; Wagner: Münch med. Wochenschr., 1888, 195; Delcourt: Rev. Mens. des Mal. de l'Enf., 1898, 329; Strümpell · "Lehrb. d. spec. Path. u. Ther.," 1884. ii., 149; Poncet: Rev. de Chir., 1897, 1003; Berard and Destot: *Ibid.*

ordinarily occurs in people of lowered vitality through want, or use of improper food. This corresponds to the arthritis pauperum, ossifying arthritis (Griffiths), and polyarthritis chronica rheumatica (Ziegler).

Rheumatic joint affections attack oftenest the knee, then the foot, elbow, hand, shoulder, hip, etc. They are monarticular or polyarticular.

For the most part, purely rheumatic affections attack youths and people of middle age.

The etiology of chronic rheumatic joint disease is but little understood. It may be primary or secondary to acute attacks. It may follow a depression in the general condition or occur as the result of exposure or more rarely from some injury.

Certain cases of joint disease resembling tuberculosis in all essential characters except perhaps in the typical muscular spasm, pursue such a benign course and are so favorably affected by anti-rheumatic remedies that, especially in rheumatic subjects, the conclusion may be warrantable that rheumatism is the cause of the affection.

IV. Gout.

The joint affection, which is the manifestation of the constitutional malady known as gout, ordinarily begins as an acute attack, and is followed by a chronic inflammatory process, increased by constant exacerbations. The synovial membrane first presents the appearances of acute inflammation; the cartilage also shows a tendency to inflammatory degeneration and erosion, and on its free surface and in its tissue, as well as in its capsule and periarticular structures, there appears a deposit of acicular crystals of urate of soda, which localized deposits are known as "tophi." The marginal growths are true exostoses (Wynne) and not as in arthritis deformans covered by proliferating cartilage. There is a permanent thickening of the synovial membrane. There is but little tendency to suppuration, unless the calcareous deposits ulcerate through the skin by pressure and so open the periarticular tissue. The common seat of the affection is the metatarso-phalangeal joint of the great toe (podagra). The joints of the hands, and the knee- and elbow-joints are also often affected.

V. Acute Infectious Diseases.

The acute infectious diseases in which joint complications may occur are as follows[1]: Measles, scarlet fever, smallpox, typhus fever, typhoid

[1] Fournier et Courmont: Rev. de. Méd., xvii., 1897, 681; Perutz: Münch. med. Wochenschr., 1898, S. 80; Fernet: Gaz. des Hôp., 1897, 1246; Vogelius 10 (ref. Virchow's 2. H. Jahresber.); Mühsam: Berliner klin. Wochenschr., 1897, 855; Brunner: Correspondenzbl. f. Schweizer Aerzte, xxii., 1892, No. 12.

fever,[1] cerebrospinal meningitis,[2] gonorrhœa, pneumonia, dysentery,[3] diphtheria, erysipelas, epidemic parotitis,[4] pertussis, puerperal fever, pyæmia, septicæmia, glanders,[5] after the use of catheters and sounds, and possibly in malaria.

The lesions occurring are now almost universally attributed to the presence in the joints of microorganisms, most often of the species causing the primary disease. The infection of the joint ordinarily is by way of the circulation, but it may extend directly or by lymph channels from some separate focus of disease (as in puerperal fever, acute osteomyelitis, or erysipelas).

The joints may develop an acute or a chronic process, serous or purulent. Nearly always the infection seems to be a synovial one, and even in severe forms the bony structures are usually but little affected. The pathological condition varies little with the special infection. There may be fibrino-purulent false membrane as a result of deposit and exudation. Still later there is suppuration of the synovial membrane, with loss of epithelium and formation of granulation tissue, fibrous degeneration, or even necrosis of the cartilages, damage to the bone ends, and destruction of the ligaments. Spontaneous luxations may occur. In a great part of the cases, however, the local infective process runs its course without great damage, and even with suppurative cases early incision is usually resorted to before the process has accomplished much destruction.

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[1] Ashby: Brit. Med. Jour., 1886, i., 970; Hodges: Lancet, 1894, ii., 1195; Bokai: Jahrb. f. Kinderheilk., 1885, xxiii., 305; Garrod, Archibald: "A Treatise on Rheumatism," 1890; Quoted in Smith and Sturge, Lancet, 1895, ii., 1212; Spiers: Montreal Med. Jour., April, 1894; Thomas: Ziemssen's Cyclop.; Hayward: Quain's Dict. Med., cited by Hodges; Henoch: Lect. Children's Dis., Syd. Soc. Tran., ii., 210 (cited by Smith and Sturge); McKenzie: Canad. Practit., January, 1893; Kummer: Rev. de Chir., 1898, 55; Ann. Surg., xiv., 483; De Loupersonne: "Les Arthrites Infect.," Paris, 1886.

[2] Griffiths: Jour. Path. and Bact., 1896–97, p. 327; Herzog: Münch. med. Wochenschr., 1898, p. 416; Eve: Clin. Jour., 1897, x., 305.

[3] Keen: "The Surgical Complications of Typhoid Fever"; Mühsam: Berl. klin. Wochenschr., 1897, 855; Sainton: Rev. d'Orth., 1892, 355; Kummer: Rev. d. Chir., 1898, 55.

[4] Osler: "Practice of Med.," p. 106 (1898 edit.); Boston Med. and Surg. Jour., 1898, cxxxix., 641; Fronz: Wiener klin. Wochenschr., 1897, x., 15; Councilman, Mallory, and Wright: Rep. State Board of Health of Massachusetts, 1898.

[5] Morel: Gaz. hebd. de Méd. et de Chirurgie, May 8th, 1898; Ziegler: "Path. Anatomie," Bd. ii., 159; Herman and Hertwig: Cited by Garrod (loc. cit.); Huette: Arch. gén. de Méd., 1869, Series vi., vol. xiv., 129 (quoted by Garrod); Thomas (of Tours): (Cited by Garrod); Revue de Médecine, 1885, p. 192.

VI. Gonorrhœa.

Gonorrhœal arthritis or gonorrhœal rheumatism are the names most commonly applied to an inflammation of the joints occurring in the later stages of gonorrhœa.

This inflammation follows no definite type; it is acute or chronic, and is most often polyarticular. Of 251 cases investigated by Northrup 56 only affected one joint; 20, two joints; 175, three or more joints.[1] In 41 cases collected by Mühsam 30 were monarticular. In 348 cases collected by Jullien 143 were monarticular.

The commonest inflammations are as follows:

Arthralgia, without definite lesions or associated with slight periarticular lesions or bursitis.

Acute synovitis, monarticular or polyarticular, resembling acute rheumatism, with considerable periarticular swelling.

Periarticular inflammation with joint effusion absent or subordinate.

Tenosynovitis occurring about the joints, but not necessarily involving them.

Chronic synovitis, serous or purulent, occurring as a sequel to the acute forms or beginning as a chronic affection. This, if prolonged, may lead to changes in the joint, such as laxity of ligaments, etc.

The effusion, if serous, is generally thick and may contain clots of fibrin. It may be sero-purulent or purulent. The effusion may be colored by blood.

In the severer cases the joint changes may not differ from those described in the arthritis due to pyæmic processes. The striking feature, insisted on by Finger, Ghon and Schlagenhaufer, Meyer, and Councilman, is the amount of granulation tissue formed. Such a process shows little tendency to involve bone or cartilage, being essentially synovial.

Ankylosis is of course to be feared. The inflammation shows the same tendency toward fibrous hyperplasia in the joints that it does in the urethra, which, of course, tends to impair joint motion. In Mühsam's 41 cases there were 7 of ankylosis. In 10 cases of Manley's none recovered with full motion, and half were followed by ankylosis. In Northrup's series the result was recorded as follows: Good, 79; fair, 69; poor, 32; no record, 72.

The affection has been demonstrated to be due to the gonococcus. The gonococci are found in the joint effusion in many cases. They are more likely to be found in acute than in chronic cases. The gonococci may be present in the pus cells of the granulation tissue, or if in the exudate, in phagocytes or in epithelial cells free or in clumps. They may,

[1] Trans. Assn. Am. Physicians, vol. x., p. 150.

however, not be found in the effusion or in sections of the synovial membrane. A mixed infection with pyogenic organisms may be found, or, rarely, pyogenic organisms alone may be found in the joint fluid. Suppuration of the joint is not necessarily associated with mixed infection.

Men are much more frequently affected than women. The complication rarely, if ever, occurs before the third week of the disease. It occurs in about two per cent of all cases, according to the statistics of Jullien, Grisolle, and Bernier. Involvement of the joints may occur after the passage of a sound into the urethra, in the vulvo-vaginitis of little girls,[1] and in the gonorrhœal ophthalmia of babies.

The joints affected were as follows in the order of their frequency in Northrup's series: Knee, 91; ankle, 57; small joints of foot, 40; wrist, 27; heel and toes, 21; elbow, 18; hip, 16; shoulder, 16; small joints of hand, 11; sterno-clavicular joint, 3; temporo-maxillary joint, 2.

The prognosis can hardly be formulated. The affection is always serious and generally slow in progress and resistant to medication. In the acute stages suppuration is to be feared, and impairment of motion, perhaps ankylosis, is not unlikely to result. Simple cases perhaps oftenest recover after a long time with practically normal motion.

The duration in Northrup's cases was:

One to six weeks	64
Six weeks to two months	54
Two months or more	77
Indefinite	57

The various treatments advised for this affection are hardly worth while enumerating. In acute synovitis the affection should be treated like other forms of synovitis and the fluid withdrawn from time to time for examination. Suppuration demands incision and drainage. Convalescent cases should be treated as if convalescent from ordinary synovitis, only with greater care.

Obstinate and persistent chronic synovitis, if in the hip, should be treated by protection, and perhaps traction by apparatus. More accessible joints are best treated by free incision and flushing out with hot sterile water or hot weak corrosive solution in obstinate cases. Drainage for a few days should be kept up by strips of gauze, and the joint should be washed out daily in severe cases. The experience of the writers has been that in such cases incision and drainage have been followed by cessation of pain and speedy restoration of motion.

The experience of the writers has not been favorable to the rubbing in of ointments (iodoform, etc.) or to the use of the many external applica-

[1] Béclerc · Revue mens. des Mal. de l'Enfance, 1892, p. 278.

tions advised. If operation is not practicable the ordinary measures in use for the treatment of chronic synovitis are to be used.[1]

VII. Pathological Conditions of the Nervous System.

A destructive form of joint disease may be associated with locomotor ataxia, syringomyelia,[2] Pott's disease, acute myelitis,[3] injuries of the peripheral nerves, cerebral apoplexy, tumors of the cord, crushing of the spinal cord,[4] and progressive muscular atrophy. A form of joint disease is described by Laborde[5] as occurring in anterior poliomyelitis.

These affections are called Charcot's joint disease, spinal or neuropathic arthropathy, neural arthropathy, tabetic arthropathy, etc.

The pathological process is in many respects similar to that in arthritis deformans except that the destructive process is more rapid and the formative activity less. The cartilage disintegrates, the ends of the bones are exposed and may be rapidly worn away, the synovial membrane and ligaments thicken and ulcerate. This process may result in spontaneous luxation in severe cases. Synovial effusion may be present, and suppuration may occur. Hypertrophy of the epiphyses may take place as well as the formation of osteophytes, but atrophic changes predominate. The essential character of the affection is the rapid melting away of cartilage and bones.

The affection is most often monarticular, and although adults are generally affected, cases have been recorded as early as the sixth year. The joints are affected in approximately the following order of frequency: In 107 individuals the knee was affected 78 times, the hip 31 times, the shoulder 21 times, the tarsus 13 times, the elbow 10 times, the ankle 9 times, the wrist twice, the jaw twice, and the spine once.

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[1] Finger: "Blennorrhœa," 1893, p. 327; Rindfleisch: Langenbeck's Archiv, vol. lv., S. 445; Finger, Ghon, and Schlagenhaufer: Arch. Derm. u. Syph., xxviii., 1894; *ibid.*, 1895; Mühsam: Mitth. a. d. Grenzgebieten der Med. u. d. Chir., ii., Hft. 5; Meyer: Centralbl. f. Chir., 1898, No. 1, p. 20; Therese: Gaz. des Hôp., 1894, lxvii., 38; Osler: "Pract. Med.," 1896; Hartley: N. Y. Med. Jour., 1887, 377; Guiteras: N. Y. Med. Jour., 1894, lix., 355; Parizeau: Gaz. hebd. de Méd. et de Chir., 1896, 953; Neisser: Deutsche med. Wochenschr., 1894, No. 15; Respighi et Burci: Ann. de Derm. et Syph., 1895, 270; Respighi: Bull. de Soc. Méd. Pisana, 1895, No. 2 (ref. Baumgarten); Rubinstein: Therap. Monatsheft, 1890, iv., 379; Bordoni Ufreduzzi: Deutsche med. Woch., 1894, 484; Brodhurst: Trans. Am. Orth. Assn., 1891, iv., 59; Tyson: Univ. Med. Mag., 1889–90, ii., 625; Bond: Westminster Hosp. Rep., 1889, v., 163; Widal: Soc. Méd. des Hôp. de Paris, 1895, 607; Manley: Am. Jour. Med. Sciences, 1894; Béclerc: Rev. Mens. des Mal. de l'Enfance, 1892, p. 278.

[2] Sokoloff: Deutsch. Zeit. f. Chir., 1892, xxxiv., 505.

[3] Mitchell: Am. Jour. Med. Sciences, April, 1875.

[4] Riedel: Berl. klin. Woch., 1883, xvii.; Joffroy: Gaz. méd. de Paris, 1872, vi. and viii.

[5] Laborde: Bull. de la Soc. d'Anat., 1873, p. 744.

So far it cannot be said that the lesion of any one set of nerve structures is the definite cause of the joint disturbance.[1]

The joint changes may be present at an early stage of the nervous disorder.

Swelling, effusion, disability, and sometimes pain are the first signs of the joint involvement. Spontaneous arrest of the process may occur, ankylosis may rarely result, or more commonly the joint is disorganized to the point of luxation. The diagnosis is often difficult, especially in the early stages. The resemblance to malignant disease is at times striking, as

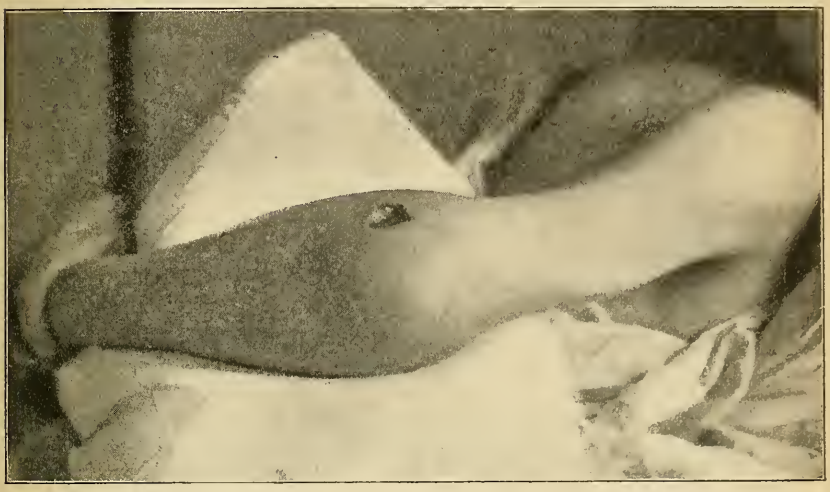

FIG. 181.—Charcot's Disease of Elbow. Opening made to obtain specimen for microscopical examination.

in a case of one of the writers shown in Fig. 181. The removal of a bit of the tissue will of course serve to establish the character of the process present.

The treatment does not differ essentially from that of inflamed joints in general. The nervous lesion must be treated, and although excision[2] has been successfully done under these conditions, local operative measures are not, as a rule, to be advised.

VIII. HEMOPHILIA, SCURVY, ETC.

Hæmophilia is accompanied at times by characteristic joint lesions which in their clinical resemblance to tuberculosis are worthy of notice. Like other manifestations of this diathesis they occur in male children or young adults, decreasing in frequency with increasing age (Gocht). The hemorrhage may be intra-articular or peri-articular. After repeated acute attacks of hemorrhage into the joint chronic joint changes are likely to en-

[1] Cf. Charcot, vol. i., p. 121. [2] Wolff: Deutsch. med. Zeit., March 15th, 1888.

sue. There is an overgrowth of brown-stained synovial tufts. The cartilage may degenerate, and sharp bordered defects in it are frequently found. Adhesions, contractions of the capsule, and bony displacements may occur.

Erosion of the ends of the bones may take place along with a proliferation at the edges not unlike rheumatoid arthritis. A brown staining of all the joint structures, except the cartilage, is described as characteristic. Rheumatic pains are a common clinical accompaniment of the affection. The character is essentially chronic. Swelling and muscular spasm are present during attacks of irritation, and the diagnosis from tuberculosis is to be made more from the history than from any characteristic features.[1]

König reports two fatal hemorrhages occurring as the result of operation on these supposedly tuberculous joints.

Protection to the diseased joints is of more use than any other one measure, but the prognosis as to recovery is doubtful at best. Aspiration with a small needle may be safely done for purposes of diagnosis.

Spontaneous bleeding into joints in persons not bleeders has been recorded (Isambert[2]).

Scurvy.—Joint affections in infantile scurvy are not uncommon. They simulate closely epiphysitis. The enlargement may be confined to one of the bones forming an articulation. The thickening is due to periarticular or rather subperiosteal hemorrhage. The joint itself is not usually unaffected, though hemorrhage may occur. Such joints yield readily to the usual treatment of infantile scurvy. Such apparent inflammation of joints occurring in scurvy is regarded as being more often due to extra-articular than to intra-articular lesions, subperiosteal hemorrhage being the most frequent lesion. In 379 cases of scurvy investigated by the American Pediatric Society[3] there were swellings in, or more often about, the joints in 165. These were distributed as follows: Knee 73, ankle 28, wrist 12, hip 6, shoulder 5, elbow 3, hand 1.

In 40 analyzed with regard to the coexistence of rickets, in 45 per cent there were symptoms of rickets, while in 55 per cent rickets was said to be definitely absent.

Pulmonary Hypertrophic Osteo-arthropathy.—This the name given to a condition occurring sometimes in connection with chronic pulmonary disease in which the fingers are clubbed and stiffened, the shafts of the

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[1] Linser: Bruns' Beitr. zur klin. Ch., Bd. xvii., 105; Shaw: Bristol Med.-Chir. Journal, 1897, xv., 240; König: Volkmann's Samml. klin. Vorträge (Transl. Med. Surg. Reporter, lxvi., No. 26, p. 999); Legg: St. Barth. Hosp. Rep., xvii., 1881, 303; Pearce: Brit. Med. Jour., 1898, i., 1135; Summers: Med. Rec., 1896, xlix., 336; Lübke: Deutsch. Zeit. f. Chir., xlix., 614; Gocht: Münch. med. Wochenschr., 1899, February 21st, 271.

[2] For normal processes of absorption of blood in joints see Jaffè: Langenbeck's Archiv, Bd. liv., Hft. 1.

[3] Boston Med. and Surg. Jour., vol. cxxxviii., 607.

bones are thickened, and the spine is bent forward in a kyphosis. The relation of the affection to acromegaly and osteomalacia is not clear.

In this condition the joints are occasionally swollen and painful with effusion. The changes as shown by autopsy[1] are synovitis and thinning of the articular cartilages even to the extent of exposing the bone. Along with this is associated periostitis and some sclerosis of bone which may involve the shaft.

IV. Miscellaneous Conditions.

Lipoma may occur in the joint beneath the synovial membrane, often causing chronic synovitis. The mass may vary from the size of an almond to that of a small egg. These growths may apparently be true lipomata[2] springing from the fat pads beside the patella, or they may be associated with tuberculosis or arthritis deformans. The form of lipoma not unusual with arthritis deformans is that showing great numbers of relatively small fatty villi, the lipoma arborescens so called.

Loose bodies in the joints are found most often in the knee, but occasionally in other articulations. The other names for the condition are, loose cartilages, joint mice, floating or movable bodies in joints, mures articulorum, corpora libera articulorum, etc. They can be divided into classes, according to their structure, as follows: fibromatous, lipomatous, chondromatous.

They are formed in one of the following ways:

(*a*) As the fibrinous residue of an exudation.

(*b*) As the residue of a blood clot, a theory which rests rather on the consensus of opinion than on accurate demonstration.

(*c*) As broken-off osteophytes in arthritis deformans.

(*d*) As hypertrophied or degenerated synovial tufts.

(*e*) As marginal ecchondroses broken off, as in arthritis deformans.

(*f*) As encapsulated foreign bodies, such as bullets and needles.

(*g*) As bits of cartilage or bone chipped off by traumatism or loosened by a degenerative process the result of traumatism.[3] The fact that a fall may be the cause of this variety of loose body has been clearly proved.

Formerly it was held that free bodies (of the chondromatous class) were the result of the direct forcible tearing off of pieces of cartilage by wrenches or strains or blows. The more modern view is represented by König, who does not deny the possibility of this tearing off of bits

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[1] Lefebre: Thèse de Paris, 1891; Ranzier: Rev. de Méd., 1891, p. 30; Trans. Path. Soc., 1896, xlvii., 177; Whitman, Pediatrics, 1899, vii., Nos. 4 and 5 (with bibliography).

[2] Stieda: Beitr. z. klin. Chir., 1896, xvi., 285.

[3] St. George's Hosp. Rep., 1867, ii., 141; Volkmann: Deutsch. Klinik, 1867, No. 48.

of cartilage, but he insists upon its rarity and shows the great force necessary to detach them in this way. Rather, it should be considered that these pieces are so bruised and injured by the trauma that their necrosis follows, and that a spontaneous osteochondritis then takes place which leads to their detachment and sets them free in the joint. Cases in which the traumatic origin of these chondromatous free bodies is beyond question are given; notably one[1] in which, three weeks after a wrench to the knee, a free body was removed by Mr. Simon, which Mr. Shattock pronounced to be a piece of the articular surface.[2]

There seems reason to believe that in spite of the lack of blood-vessels these bodies are nourished, after being set free in the joint; not only does ossification of them take place after they are freed, but the case of Recklinghausen would seem to show that growth is also possible.

Loose bodies lie free in the joint or are attached by a slender pedicle. They may vary in size from that of a small pea to that of a horse chestnut, and are of all shapes. The smaller ones are most often shaped like melon-seeds, or are irregularly round, while the larger ones are more regularly round, concavo-convex, or spherical. Sometimes they are facetted and crowded together like the carpal bones, and again they are mulberry-shaped or pyriform. In one joint they may appear singly or in great numbers, and they may vary a great deal in size in the same joint. Over four hundred have been removed from one knee-joint.[3] Next in frequency to the knee comes the elbow,[4] and all of the larger joints are liable to contain these bodies. In external appearance they are whitish or yellowish, and vary from a soft consistency to a bony hardness. On section they show either a plain fibrous structure, or a fibrous sheath enclosing a mass of fat. Again, the structure is of hyaline or fibro-cartilage, ordinarily without corpuscles, or of bone tissue, most often without Haversian canals. Frequently they present a combination of two of these forms.

They are often found in connection with the changes known as arthritis deformans, and also in joint disease of various types. They may be found in connection with joint tuberculosis. In certain cases no cause can be assigned for their occurrence.

Joint Disease Secondary to Peri-articular Abscess.—Suppuration in the periarticular cellular tissue and subsequent affection of the joint may start from an open skin wound which has been infected, or from an in-

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[1] Marsh: Brit. Med. Jour., April 14th, 1888.

[2] Shattock: Path. Trans., xv., p. 206.

[3] Howard Marsh: "Diseases of Joints," p. 183; Barwell: "Diseases of Joints," p. 268. London, 1881.

[4] König: Arch. f. klin. Chir., 1888; cf. Brodhurst: St. George's Hospital Reports, 1867, ii. s., 141–144, and Volkmann: Deutsche Klinik, 1867, No. 48; "Die krankhaften Geschwülste," p. 450, Berlin, 1863.

jury to the limb in which cellulitis has come on in consequence of the trauma. Again, in children of feeble type, periarticular abscess of a slow and chronic character may arise after slight bruises, and sometimes after no perceptible injury at all. Any of these abscesses, if they are not at once evacuated, are, of course, likely to infect a neighboring joint; occasionally, the abscess from one diseased joint burrows a long distance, and in its course either opens into another joint or passes so near to it that infection of the second joint takes place.

Growing Pains.—A joint affection incident to growth has been described by Bouilly, and has long been known but unclassified by practitioners, and popularly considered to be incident to growth—"growing pains." There is slight pain chiefly in the juxta-epiphyseal region, most commonly near the lower epiphysis of the femur. This pain is brought on by fatigue, strains, or exposure. In the lightest cases the symptoms pass away in a few hours. In severer forms they may last for several days, and the pain may be accompanied by slight fever. In the severest form the affection may continue for months. There may be slight effusion in the joints, but recovery eventually takes place. It may occur during the ages between five and twenty-one.[1]

A great amount of harm is done in referring to this class the pains of beginning chronic joint disease. Growing pains proper are neither severe nor permanent.

Analogous to this may be mentioned what has been termed by French writers maladie de la croissance—which is in reality a hyperæmia and sensitiveness of the epiphysis in adolescents—analogous to what is seen occasionally in rickets.

Ankylosis is the name applied to the stiffened condition of a joint. It is often subdivided into two classes, true ankylosis when the union is bony, and false ankylosis when it is fibrous. But this subdivision is not universally accepted. Ankylosis is most often the result of joint inflammation, the products of which inflammation are transformed into fibrous tissue. If the inflammation has been severe enough to expose the ends of the bones they may be united by a connecting formation of bone. The same joint may in part be obliterated by connecting bone while in other parts of the same joint fibrous connecting bands exist. The character of the ankylosis, whether fibrous or bony, depends in large measure upon the character and extent of the inflammation causing it. The limitation or prevention of ankylosis in joint disease obviously depends upon the efficient treatment of joint inflammation.

The fixation of healthy joints for a reasonable time cannot be considered as likely to produce ankylosis. A degenerative rather than an inflammatory process was found in healthy joints immobilized by Reyher for a year.

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[1] Gaz. des Hôp., 1883, p. 1034.

Among joint inflammations causing ankylosis by virtue of their process of repair may be mentioned especially synovitis, particularly of the purulent form, and tuberculosis of joints.

Intra-articular fractures, especially with displacement of bone, must be accounted as a frequent cause of ankylosis.

Cicatricial contraction of the joint capsule as well as connecting fibrous bands may cause the loss of motion in a joint.

The name ankylosis should not be applied to the stiffness of joints due to the tonic muscular spasm of acute or chronic joint disease.

In bony ankylosis it is evident that nothing but a cutting operation can be of use. If such joints are fixed at improper angles, excision or osteotomy of the joint may be performed, followed by a replacing of the joint at a proper angle when ankylosis will again occur, but in a different position. An elbow ankylosed in a straight position is a disabling deformity, but the same arm is of much use when the elbow is fixed at a right angle.

The success of other treatment, such as manipulation and stretching, in the fibrous form of ankylosis will depend on the character and resistance of the fibrous bands constituting the ankylosis. The patient may be etherized and manipulation be attempted. If the ankylosis is bony nothing can be accomplished. If the fibrous bands are very resistant motion cannot be obtained and the use of extreme force will do more harm than good in starting up fresh inflammation. If the fibrous bands are few and small they may be stretched or ruptured by the use of moderate force, and if the following joint inflammation is not severe much may have been gained. Such forcible manipulations must be followed by passive motion at frequent intervals. Gentle manipulation from the first in connection with massage is preferable to the use of force in suitable cases. The question of ankylosis has been discussed under the various joints. Massage, hot-air baths, and the use of elastic and mechanical force are all of use in connection with manipulation.

Bursitis.—The inflammation of bursæ may easily lead to an affection of the joints. The more frequent of these forms of bursitis will be described in speaking of the individual joints.

As other causes of impairment, rather than disease, of joints, may be mentioned the following: cicatrices after burns, wasting of muscles and ligaments after infantile paralysis, and muscular contractions causing malpositions of the joints after hemiplegia, fractures involving the joints, etc.

CHAPTER V.

HIP DISEASE.

Definition.—Pathology.—Clinical history.—Diagnosis.—Differential diagnosis.—Prognosis.—Treatment (mechanical—operative).

The affection which is commonly known as hip disease is the most frequent affection of the hip-joint, and by common usage the general name of "hip disease" or "hip-joint disease" has become limited to that especial affection of the joint which comes now for consideration. It is known also by the names of morbus coxarius or morbus coxæ, coxalgia, coxitis, chronic articular ostitis of the hip, and coxo-tuberculose (Lannelongue). The pathological condition commonly found is a chronic tuberculous ostitis of the epiphysis of the head of the femur or of the acetabulum.

Pathology.

The pathology of hip disease has already been considered in its general aspect along with the other forms of tuberculous joint disease in the previous chapter.

Although probably in most cases[1] the head of the femur is the primary seat of disease,[2] in others the acetabulum is the part first affected.[3] In Wright's 100 cases the acetabulum was necrosed or perforated in 27, in 14 of which there seemed reason to believe that the femur was first affected. In 49 other cases, however, the acetabulum was superficially diseased.

When once the acetabulum has become diseased either primarily or secondarily, enlargement of it is apt to take place. The irritated pelvic femoral muscles which are in a state of tonic contraction crowd the head of the femur against the upper and back border of the acetabulum; under this continual pressure absorption of that portion of the rim of the acetabular cavity takes place with an actual enlargement of the cavity from below upward. This so-called migration of the acetabulum is one

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[1] König: Deutsch. Zeit. f. Chir., xi., 1879.

[2] König: "Die Tuberc. der Knochen und Gelenke," Berlin, 1884; G. A. Wright: "Hip Dis. in Childhood," p. 17.

[3] Habern: Cent. f. Chir., April 2d, 1881; E. H. Nichols: Orth. Trans., vol. xi., p. 353.

cause of shortening of the limb, and measurement will show that the trochanter lies above Nélaton's line.

The changes in the head of the femur are chiefly the result of ostitis and pressure. There may be alteration in the shape of the head of the

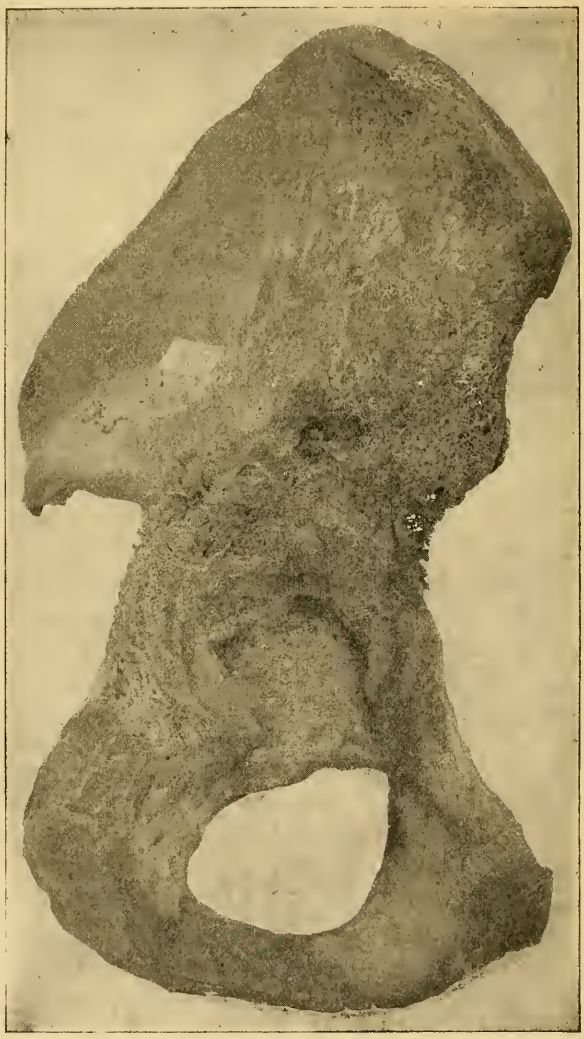

FIG. 182.—Erosion of the Upper Part of the Acetabulum. (New York Medical Journal.)

bone, if it is worn away by the pressure induced by constant muscular spasm and destruction of the articular surface. The appearance of the cartilage, as described under the pathology of that structure, often suggests ulceration, and hence arose the theory that the original seat of hip disease was to be found in the cartilage.

"Dislocation" of the hip in hip disease is a term often used which is perhaps misleading. True dislocation in ordinary tuberculous ostitis of the hip rarely occurs, but partial destruction of the softened head of the

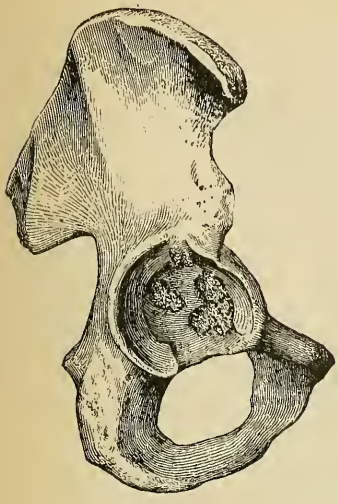

FIG. 183.—Pathologically Enlarged Acetabulum.

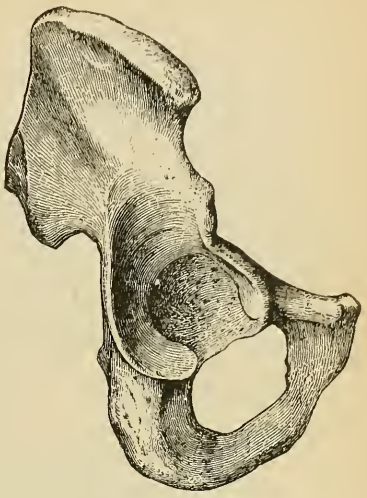

FIG. 184.—Acetabular Coxitis.

femur in the manner just described may lead to a shortening of the limb and to an elevation of the trochanter above its proper level. The wearing away of the acetabulum produces the same result; but true disloca-

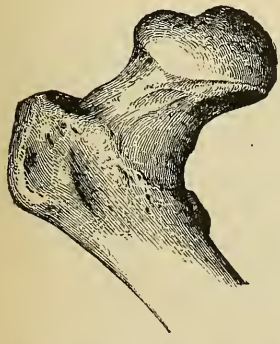

FIG. 185.—Erosion of the Head of the Femur.

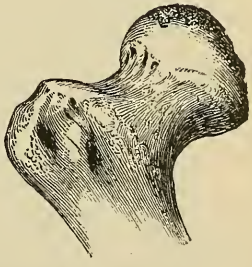

FIG. 186.—Erosion of the Head of the Femur.

tion is rare, because, even if the head of the bone is almost entirely destroyed, there is so much inflammatory tissue deposited about the joint that the head of the bone is retained partly in place.

Fracture of the atrophied and degenerated shaft of the femur may occur in occasional cases. Separation of the head of the femur at the epiphyseal line is less uncommon (Fig. 188).

A typical specimen from a fairly advanced case of hip disease shows a reddened and thickened synovial membrane, perhaps even broken down into granulations; the cartilage is gone from the head of the femur or

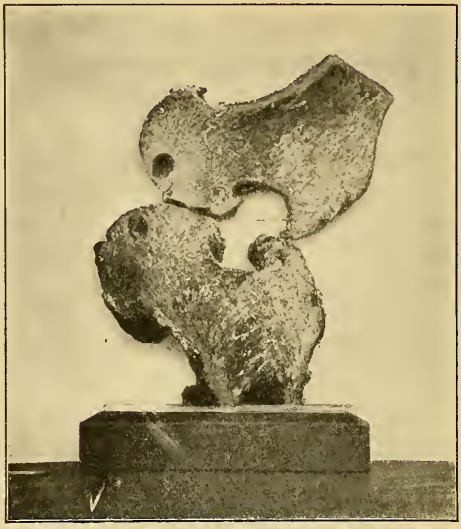

FIG. 187.—Focus in Head of Femur.

hangs in tags or shreds, and the general appearance of the end is often spoken of as "worm-eaten"; sometimes the whole cartilage may be lifted

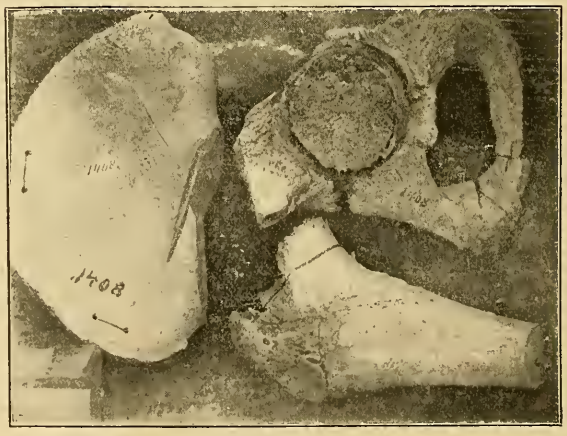

FIG. 188.—Separation of the Head of the Femur at the Epiphyseal Line.

from the bone by a layer of granulations. The epiphyseal portion of the head of the femur has disappeared in part or altogether, and a ragged,

carious end of bone will articulate with an acetabulum covered with fungous granulation in part or wholly replacing cartilage.

The whole epiphysis may form one sequestrum, but this is not common. Sometimes it lies in the epiphysis, but more commonly it extends on both sides of the epiphyseal line; while sometimes the dead bone extends some little distance into the diaphysis.

Perforation of the floor of the acetabulum may take place. Inside of the pelvis a dense wall of fibrous tis-

FIG. 189.—Head and Neck of Femur from Excised Hip. Head denuded of cartilage. No primary focus found. *a*, Head denuded of cartilage; *b*, neck. (Nichols.)

FIG. 190.—Hip Disease. Process extended from primary focus in acetabulum along round ligament. *a*, Head of femur covered with elevated cartilage; *b*, neck. (Nichols.)

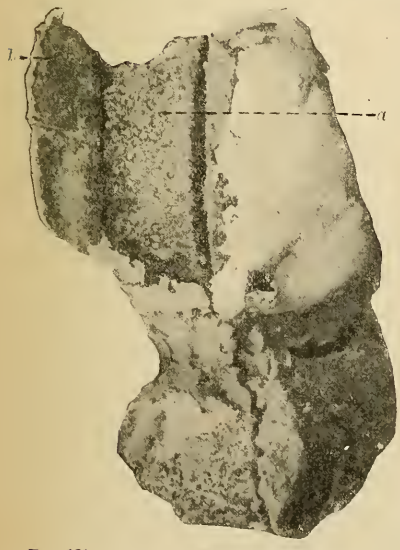

FIG. 191.—Hip. Excised head of femur. Articular cartilage turned up at one side shows tuberculous bone beneath. Primary focus was in acetabulum. *a*, Head of femur, surface tubercles; *b*, elevated cartilage. (Nichols.)

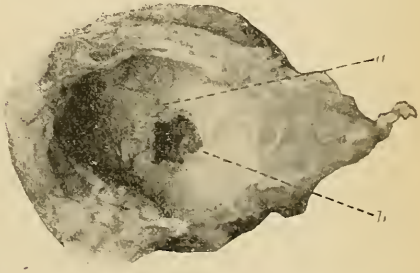

FIG. 192.—Acetabulum seen from Outside. *a*, Tuberculous granulations; *b*, tuberculous cavity. (Nichols.)

sue and thickened periosteum shuts off the head of the femur or the contents of the joint from the pelvic cavity. In cases in which the disease has gone on as far as this, disease of the pelvic bones may coexist. In the other direction, when once the disease of the femur has passed the epiphyseal line, there is no limit to be set to its course or its extent of destruction.

FIG. 193.—Hip. Section through femur and acetabulum. Some erosion of acetabulum upward. Ankylosis without dislocation. *a*, Ankylosis; *b*, head of femur; *c*, acetabulum. (Nichols.)

Abscesses appear externally if the disease of the joints extends to the periarticular tissues, or when a separate focus of disease forms outside of the joint and spreads to the surrounding soft parts. Suppuration inside of the pelvis is not a very uncommon condition in the acetabular form of the disease; in the femoral form it accompanies only advanced disease. It arises most commonly from perforation of the acetabulum or from inflammation inside the pelvis excited by the bone disease in the neighborhood; or, again, the pus may ascend to the brim of the pelvis, either in the sheath of the psoas muscle or in other tissues, and then gravitate down the inner wall.[1]

A natural cure results in one of two ways: by the absorption or calcification of the tuberculous tissue at an early or a late stage of the disease; or by the purulent degeneration of such tissue and its evacuation and discharge by an external opening. The suppuration which comes later seems to be nature's effort to eliminate the diseased material, and it is the common method by which spontaneous cure results when it does occur. This late stage of the disease is characterized by malpositions

[1] R. W. Parker: Chir. Soc. Trans., 1880.

and shortening of the limb and much impairment of the general condition in most cases. It is this state of affairs that makes the spontaneous cure of hip disease undesirable and imperfect. When spontaneous cure does occur it is usually with an ankylosed joint. The articular surfaces have been destroyed by the disease and, in part of the joint at least, eroded granulating bone surfaces are in contact. These surfaces become united by adhesions, or ossification of the cicatrizing tissues may eventually take place and all the parts solidify into one mass.

FIG. 194.—Head of Femur Eroded, Partly Destroyed, Partly Dislocated. Fibrous ankylosis. *a*, Head of femur; *b*, eroded head of femur; *c*, ankylosis; *d*, acetabulum. (Nichols.)

In these cases, however, one sometimes finds at autopsy an included cheesy focus which still presents some signs of activity. It is to these foci that one looks for an explanation of the late relapses of the disease and the very great harm which is sometimes done by forcible manipulation of these joints and consequent lighting up of the original tuberculous disease.[1]

CLINICAL HISTORY.

Early Symptoms.—The beginning of the affection is most often gradual and insidious, but at times it begins so abruptly, according to the parents' account, as to suggest a traumatic origin. The child will be noticed to limp at times with intervals of comparative freedom from lameness. This lameness increases, and it will be found that the patient is inclined to strike the ball of the foot rather than the heel in walking; although the heel can be put down to the floor, yet instinctively the knee is slightly bent and the heel raised when the weight of the trunk falls on the hip. There is a certain amount of stiffness of gait apparent in the

[1] Trans. American Orthopedic Association, vol. i.

morning when the patient first gets out of bed, and after sitting for a while; this passes away after the patient has walked or played about. At night, as a rule, the limp is less than in the morning. The limp can perhaps best be described as a very slight stiffness and a disinclination to bear prolonged weight upon the affected limb.

If the child be inspected it will be seen that, although able to run about and play freely, there is a noticeable limp, and that in standing

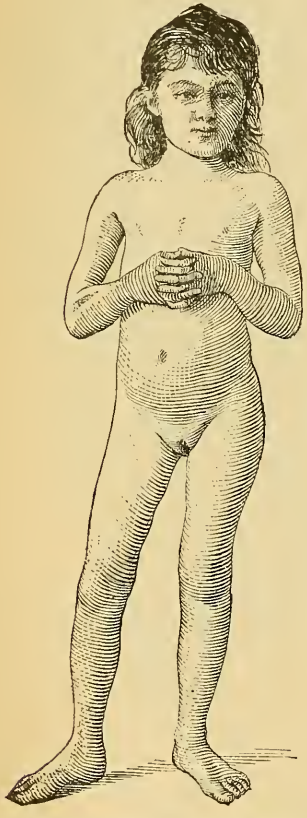

FIG. 195.—Position Assumed in Standing, with Slight Abduction of the Right Leg.

FIG. 196.—Tilting of the Pelvis and Abduction of the Thigh in Hip Disease.

the knee of the affected side is often flexed slightly, the pelvis being tipped and the thigh slightly abducted. The tilting of the pelvis and abduction of the thigh may be so slight that it is scarcely noticeable, except by the deviation from the median line of the fold between the two buttocks. In girls the vulva on the affected side may be lower than on the other side.

Pain at this stage is very often absent, and if present is noted as night cries, to which allusion will be made.

It has been customary to divide hip disease into stages and to ascribe to these stages certain definite symptoms. Neither from a clinical nor a pathological standpoint is it desirable to attempt any such division.

In the early part of the disease, pain at night, stiffness, and limping are the chief symptoms. Then follow malpositions of the limb, more severe disability, and perhaps greater pain and sensitiveness. Abduction of the diseased limb is a little the most common of the malpositions of the early stage, but adduction is by no means uncommon as an early symptom. Later in the course of the affection adduction is more frequent than abduction.

Fig. 197.—Flexion and Abduction. (From a photograph.)

Succeeding the deformities which have just been described, one may find abscess formation and the development of sinuses; and this stage of the affection will hardly have been reached without considerable constitutional deterioration, which may become severe.

Lameness.—From being at first scarcely perceptible, the lameness increases and the limp becomes very noticeable. In very acute cases pain may become so severe that the child will refuse to use the leg, or malposition of the leg may come on rapidly and the limp may on that account become excessive; but in general the child walks without pain, though perhaps limping badly. Until the late stages of the disease lameness is not due to bone shortening.

Pain.—As the affection progresses, pain in the knee and sensitiveness to jarring the limb may become prominent symptoms. An unconscious protection of the joint may be noticed in the movement of the patient; the foot of the well limb may be placed under the lower part of the other leg when it is to be suddenly lifted by the patient, as from the floor to the bed, or from the bed to the floor, or in moving from one side of the bed to the other.

In manipulating the leg at this stage pain may follow the slightest jar to the joint, or, on the other hand, the joint may be perfectly stiff from muscular spasm and yet manipulation may be wholly painless. In other cases motion in a certain arc is possible without causing pain, but when the limits of this arc are reached, further motion becomes painful or is prevented by muscular fixation. The sensitiveness of the joint may become so great, when an acute stage supervenes, that the slightest move-

ment of the patient, or jar of the bed or room, causes extreme suffering. This stage may come suddenly and gradually pass away, the pain diminishing by degrees under the enforced treatment of rest, or it may be persistent. A characteristic position is frequently taken by the patient, who places the well foot on the dorsum of the foot of the affected limb, exerting pressure away from the acetabulum. *Pain may be absent at any or all stages of the disease, and is not a diagnostic sign for or against the presence of hip disease.* Sensitiveness may be absent, upon which condition, however, at any time a sensitive condition of the joint may supervene. The pain is often remittent, and here, as in all the symptoms of this affection, marked remissions may occur. The location of the pain is variable, but is generally referred to the inside and front

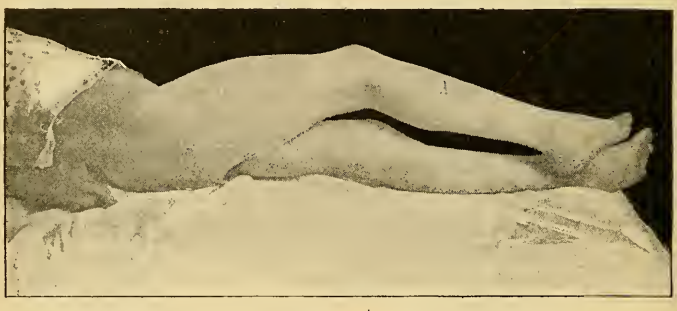

FIG. 198.—Instinctive Effort at Traction in Acute Disease of the Left Leg. (Fiske Prize Fund Essay.)

of the thigh near the knee or directly at the knee-joint. The intimate relations and anastomoses of the sciatic, obturator, and anterior crural nerves seem to furnish the best explanation of this.[1]

Attempts have been made to differentiate the varieties of hip disease by the location of the pain, but no reliance can yet be placed upon such a classification.

In a minority of cases the pain is referred to the joint itself. In the more acute cases sensitiveness to pressure on the trochanter and to deep pressure over the anterior surface of the joint (just below the anterior superior spine of the ilium) is present.

Night Cries.—At an early stage of the affection the symptoms of "night cries" often appear. They occur in the early part of the night usually, and may become an annoying symptom. After the patient is asleep, and to all appearance entirely unconscious, sleep will be interrupted by a cry as if of severe pain, followed by moaning or crying for a few seconds; the child being unconscious or only half-conscious of the cause of the pain. These do not often occur when the patient is entirely awake, and are caused by the spasmodic twitching of the muscles abnor-

[1] G. A. Wright: "Hip Disease in Childhood," p. 35.

mally excitable from irritation reflex to the inflammation of the joint. These cries may be repeated fifteen or twenty times during the night. They do not occur in the latest stages of the disease, and may be entirely wanting in the mildest cases. They resemble somewhat the cry in the "night terrors" of nervous children, but differ from those in that there is greater evidence of extreme pain, and no connection with unpleasant dreams, apprehension, or fright. From the testimony of patients old enough to explain symptoms, the pain is reported to be extremely sharp and severe, suddenly interrupting sleep and awakening one, and leaving an ill-defined sense of an aching in the thigh and hip as if the hip had sustained a blow.

Muscular fixation is always present in some degree, restricting the joint's normal arc of motion. It is due to a reflex irritability of the muscles controlling the joint which causes them to maintain a condition of tonic spasm of greater or less degree. This will be discussed more fully under the head of diagnosis. Here it may be said that rest to the joint and thorough treatment tend in time to restore motion to the diseased part, and that if a child is taken under treatment with a joint perfectly rigid from this cause it is to be expected that under treatment the joint will become more movable unless the disease is very acute. Increased stiffness appearing in the course of treatment is a sign of inefficient treatment or of increase of the disease. This muscular rigidity is the most important sign of the disease, for not only is it the chief reliance in the matter of diagnosis, but it is the cause of the malpositions of the limb, of the wearing away of the acetabulum and of the head of the bone, and it lies at the root of much of the pain. It furnishes the most accurate index of the progress of the case, and improves or becomes worse as the case becomes better or worse. The importance of the recognition and accurate study of this symptom cannot be overestimated.

A symptom of acute hip disease which has not received due attention is a muscular irritability of the lower erector spinæ muscles as well as of the muscles directly controlling the hip-joint. If a child with a severe hip disease be laid on his face and lifted by the legs with a view to determining the flexibility of the lumbar spine, one can often notice the lumbar muscles stand out like cords, and hold the lumbar spine quite rigid. This often gives rise to the suspicion of the coexistence of Pott's disease. This symptom is present only in the severer forms of hip disease.

Atrophy.—A marked atrophy of the muscles of the thigh, hip, and leg is characteristic. It is supposed to be reflex to the disease of the joint.[1]

Atrophy of the muscles controlling an inflamed joint begins early and may be very marked, even in simple acute synovitis. That this is some-

[1] Emile Valtat: "L'Atrophie Musc. dans les Mal. Articulaires." Paris.

thing more than the mere atrophy of disuse is shown by the fact that it begins so sharply and so early, that it is greater in the diseased limb than in the well one even when the patient has been in bed from the first, and that the muscles, although atrophied, are not soft and flabby, but tense. Valtat injected the joints of guinea-pigs and dogs with irritant solutions, mustard oil and ammonia, and found that muscular atrophy came on quickly. In one case, in eight days there had been a loss of thirty-two per cent by weight in the anterior thigh muscles, and twenty-four per cent in the anterior calf muscles; in another case it reached forty-four per cent, and in all cases the extensors wasted more rapidly than the flexors. He attributes much influence in the matter to the amount of pain present, a point already clinically noted by Paget. Valtat also calls attention, in this connection, to the paralysis of the muscles of the affected limb often accompanying acute joint disease. In a case of knee-joint synovitis, which he mentions, there was complete

FIG. 199.—Severe Flexion in Hip Disease. (Fiske Prize Fund Essay.)

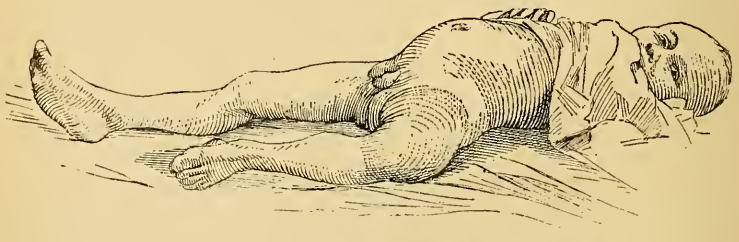

FIG. 200.—Severe Abduction and Eversion in a very Acute Case.

paralysis of the flexors of the leg at the end of twenty-four hours. Such a paralysis, to a greater or less degree, seems to precede the wasting of

the muscles. It may be noted here that increased patellar reflex is generally present in the affected leg during the early part of the disease and that the thigh muscles show a diminished contractility to the faradic current.

This atrophy generally can be easily appreciated at an early stage of the disease by grasping the muscles in the hand or by measurement with a tape. The difference in the circumference of the two thighs will be perhaps one-quarter of an inch to an inch, and the difference in the size of the calves is generally about half of the thigh difference. In children who can use the leg fairly well there is rarely any calf atrophy at the first examination. The obliteration of the fold of the buttock on the affected side is a result partly of muscular atrophy and partly of the peri-articular swelling which accompanies the disease. It is a common but not a constant symptom at the early stages of the disease. It is also partly due to the flexed attitude of the limb, which naturally diminishes the prominence of the buttock on that side.

Fig. 201.—Flexion and Adduction of Left Leg. (Fiske Prize Fund Essay.)

Malpositions of the Limb.—The fixation of the diseased limb in a distorted position is one of the commonest incidents of the affection. This is due to the tonic muscular contraction so often alluded to. These malpositions may hold the limb in flexion, adduction, abduction, or eversion, or in any combination of these; the cause which determines the kind of malposition in an individual case cannot be formulated. Flexion of the thigh was originally supposed to be due to an effusion in the capsule of the hip-joint, but it is seen along with adduction and abduction in cases in which no effusion has taken place. It is chiefly due to the muscular contraction, which is constant in chronic disease of the joint, and partly to an unconscious effort on the part of the patient to assume a position most comfortable for the joint and most protected from jar.[1] This

[1] Lannelongue: "Coxotuberculose." Paris, 1885, Hilton: "Rest and Pain." London.

fact has been alluded to by Sherman, of San Francisco,[1] deformity being largely due in his opinion to the unconscious assumption on the part of the patient of the position most protected from joint strain or injury.

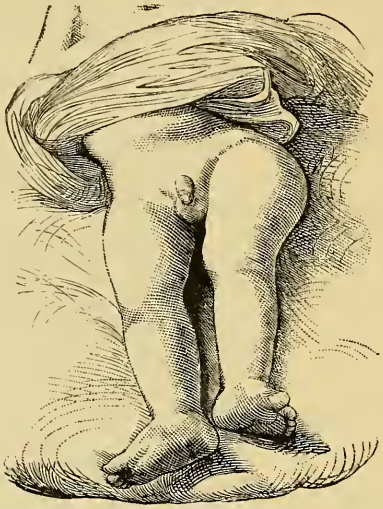

FIG. 202.—Adduction of the Left Leg in Acute Hip Disease

These deformities generally disappear under treatment by rest or traction; but again, they reappear in cases under treatment if treatment has not succeeded in checking the progress of the disease, and they go hand-

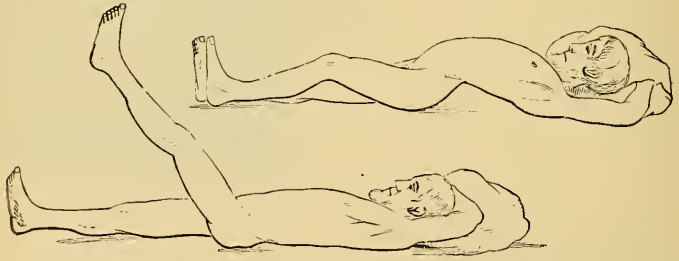

FIG. 203.—Lordosis Resulting from Bringing the Flexed Leg in Hip Disease Parallel to the Other.

in-hand with a sensitive condition of the joint which may be the precursor of abscess.

If the malposition is allowed to become permanent the final result can never be so good as when cicatrization takes place in a more normal position. The limp in ankylosed limbs depends more upon the amount of flexion and adduction than on anything except perhaps the bone shortening.

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[1] Orth. Trans., vol. xii.

It is, therefore, of much importance to diminish in all cases the amount of malposition present.

When adduction is present in both legs, as in double hip disease, and ankylosis of both hips has occurred, cross-legged progression is made necessary on account of the inability to separate the legs.

The position in standing and lying is modified by the occurrence of these malpositions; abduction or adduction causes tilting of the pelvis and flexion causes a marked lordosis of the lumbar spine in standing with the legs parallel; by standing with the diseased leg somewhat flexed the lordosis can be overcome. The same arching of the lumbar spine occurs when the patient lies on a table and the flexed leg is brought down.

Peri-articular Symptoms.—A density in the superficial tissues over a diseased hip which the other side does not possess is often found at a comparatively early stage of the affection. Behind or in front of the trochanter the deep tissues are resistant and the fossa existing there is filled out, and the great trochanter feels enlarged and thicker than its fellow when grasped by the fingers deeply pressed in.

The inguinal glands of the affected side, sometimes of both sides, are often enlarged and they may be so much distended that they obstruct the venous return and the skin may be marbled with superficial veins. They are at times the seat of superficial abscesses. In very severe cases the upper part of the thigh and the tissues in the vicinity of the hip may become swollen generally from an œdema of the periarticular tissues. This may disappear or become localized in the formation of an abscess. A thickening over the tensor vaginæ femoris is often to be felt.

Abscess.—In a proportion of cases suppuration takes place. The site and course of the abscesses vary according to the seat and size of the original focus of the ostitis, whether in the femur or acetabulum. Abscesses may be entirely peri-articular, if the initial lesion of the epiphysis extend in a course outside of the joint; or they may come from suppuration within the joint; or having been peri-articular, they may later involve the joint.

The invasion of the abscess is frequently without constitutional disturbance, exacerbation of pain and joint symptoms is, however, a frequent accompaniment of this formation. Abscesses may be absorbed or may evacuate themselves spontaneously either completely or partially, the residual fluid following along the course of the sheaths of the muscles and the fasciæ, reappearing later as secondary abscesses, the same abscess causing five or six fistulous openings. These openings discharge pus and serum for months and years in most cases. These sinuses after a short time become infected with pyogenic organisms. With the bursting of an abscess and the discharge of any considerable quantity of pus the patient's condition may show rapid improvement, or if imperfect drain-

age takes place, reappearance of the abscess may occur and the patient's condition may become worse.

When the pus has left the joint it generally burrows between the thigh muscles to reach the skin, where it appears as a swelling of varying size. Fluctuation is usually marked. As the abscess invades the skin the latter becomes thin and red, and ulcerates in one or two places, evacuating the abscess. The contents of the abscess may, however, in a few instances be absorbed even at a stage when fluctuation is marked, and the swelling may disappear, perhaps leaving a depression beneath the skin.

The pus most commonly reaches the skin at the anterior border of the

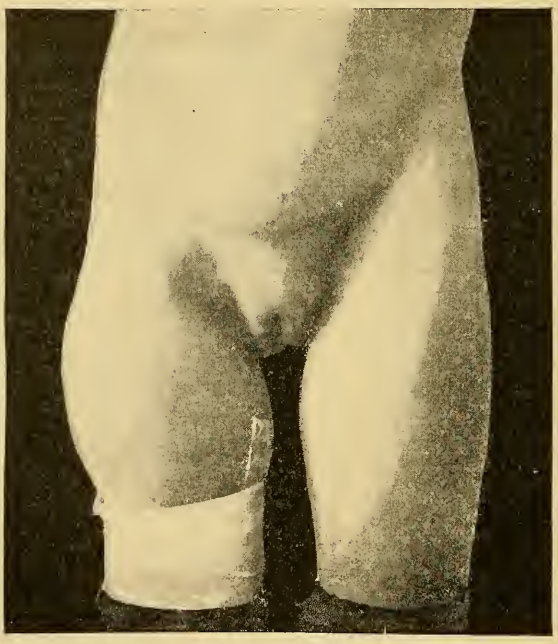

FIG. 204.—Hip Abscess, with Deep Fluctuation at the Anterior and Upper Part of the Thigh. (Fiske Prize Fund Essay.)

tensor vaginæ femoris muscles; it may, however, gravitate backward and open back of the great trochanter or at the lower border of the glutæus maximus; it may come around to the inner side of the thigh and perhaps open in front of the adductor tendons or even discharge into the rectum; finally, it may ascend the sheath of the psoas muscles and point above Poupart's ligament, or it may descend in the thigh muscles and point in the popliteal space. It has been said that the seat of the primary disease can be inferred by the situation of the abscess, but enough facts have not yet been obtained to justify such a generalization.

Probably abscess is very often the result of inefficient treatment. This has been the experience at the Boston Children's Hospital.[1] As the

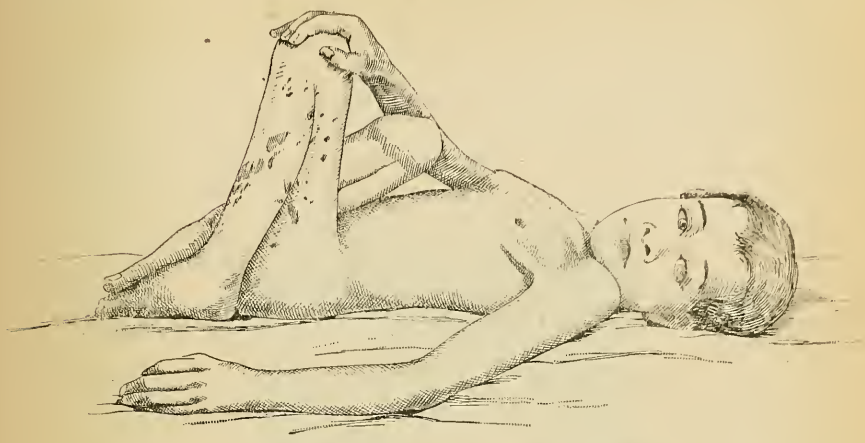

FIG. 205.—Deformity in Untreated Double Hip Disease.

treatment has become more thorough the number of abscesses has diminished.

Shortening.—The effect of persistent muscular spasm of muscles about the hip-joint, characteristic of hip disease, is to crowd the femur against the acetabulum and to produce the enlargement of the acetabulum and the absorption of the head of the femur, with resulting shortening of the limb.

In addition to the shortening produced by absolute destruction of bone in the femur or the acetabulum, there is a decided trophic disturbance of the limb which results in retarding the bony growth and probably causes at the same time a certain amount of bone atrophy; retarded growth of the affected limb becomes evident in the early months of the disease, and is a permanent condition which is not outgrown as years go on, for the affected limb always lags behind the other in its growth.

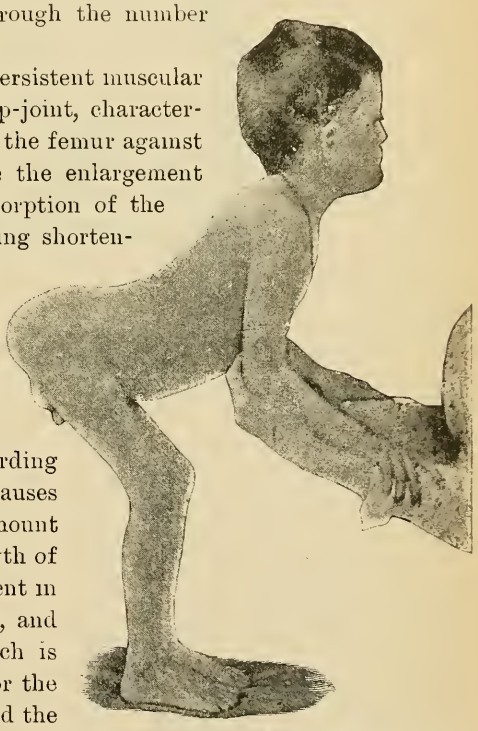

FIG. 206.—Position Necessitated by the Permanent Flexion Deformity Resulting from Double Hip Disease.

The shortening may be evenly

[1] Lovett and Goldthwait. Ortho. Trans., vol. ii., p. 82.

distributed between the bones of the leg and those of the thigh, or it may be most marked in the bones of the leg. When there is much shortening of the leg, the foot of the affected side is also smaller than the other. The difference in the length of the legs almost always increases slightly after the disease is cured, as was shown in the series of cured cases of hip disease analyzed by Shaffer and Lovett.[1]

General Condition.—Children with hip disease are often robust at the beginning of the affection and sometimes the general condition continues

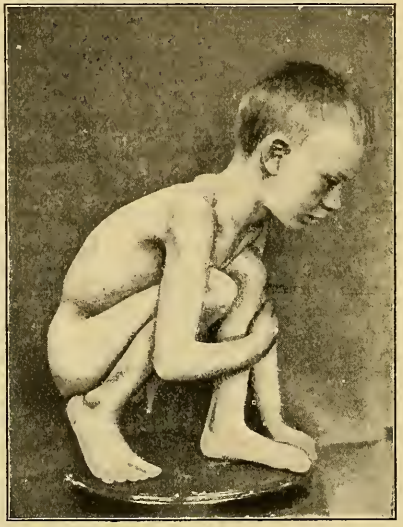

FIG. 207.—Progression in a Case of Severe Double Hip Disease.

good to the end, but these cases are exceptional. More often the child is pale and the appetite fails at times; there is often loss of flesh; in some mild cases and in most of the severe ones decided constitutional disturbance results.

Remissions.—Any account of the symptoms of hip disease would be incomplete without speaking of the remissions in the course of the affection. In the early stage this is especially noticeable, and a patient may to outside appearances entirely recover from the symptoms of pain, lameness, and discomfort for some days or weeks. Then the symptoms return with increased vigor, perhaps to disappear again in a short time. The muscular stiffness does not wholly disappear at these times, although it may improve along with the other manifestations of the disease. The later course of the disease is marked by much greater uniformity, but even then temporary improvement may be quite marked.

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[1] N. Y. Med. Jour., May 21st, 1887.

Temperature.—Children with hip disease under treatment by ambulatory measures have as a rule a higher afternoon temperature than normal. In 627 observations made on cases of hip disease and Pott's disease at the Out-Patient Department of the Children's Hospital a rise of temperature of one or two degrees was common. Ninety per cent of all cases, acute or chronic, mild or severe, had an evening temperature of at least 99°, and a rise to 103° or 104° in severe cases was not necessarily an indication of abscess.

Double Hip Disease.—The disease seldom begins in both hip-joints at the same time, and the second joint may become inflamed while the patient is under treatment in bed for the first joint.

The course of double hip disease would appear to vary somewhat from that of single hip disease. The amount of pain suffered in the joint last affected is usually less than that of the first joint, probably because there is less jar or motion when two hip-joints are affected than when one is.

Malpositions are more than usually troublesome and may be different in the two hips. Recovery without deformity and with as much motion as possible is most important in double hip disease.

Diagnosis.

The diagnosis of hip disease may be easy or difficult; in the earliest stages, errors in it are sometimes made, and care is necessary for a positive diagnosis in any stage. The most common error is the belief that the presence of pain or tenderness is necessarily present in hip disease, and that its absence excludes the possibility of hip disease. Another error often made is to look for "grating" in the joint as a sign of the disease. That sign is to be obtained only by the use of an anæsthetic by which means the muscles guarding the joint are relaxed and then only in advanced cases when two bony and eroded surfaces lie in contact.

The diagnostic symptoms in hip disease which should be borne in mind in making a diagnosis of hip disease are as follows:

1. Muscular spasm (stiffness of the joint or limitation of its motion).
2. Lameness.
3. Attitude of the limb standing, or walking, or lying (adduction and abduction of the limb), and shortening.
4. Atrophy.
5. Swelling.

These symptoms vary in prominence at different stages of the disease.

It may be said that the early diagnosis must be made chiefly by the symptom of muscular rigidity. The absence of pain or sensitiveness counts for nothing and atrophy is not characteristic. The limp is peculiar, but a similar one is present in other conditions.

Muscular Spasm.—The chief diagnostic sign in hip disease, upon

which the chief reliance must always be placed, is *the presence of stiffness of the joint or limitation of its proper arc of motion* when the limb is passively manipulated. Except in the very earliest stages there can be no hip disease without a perceptible limitation of motion. This limitation

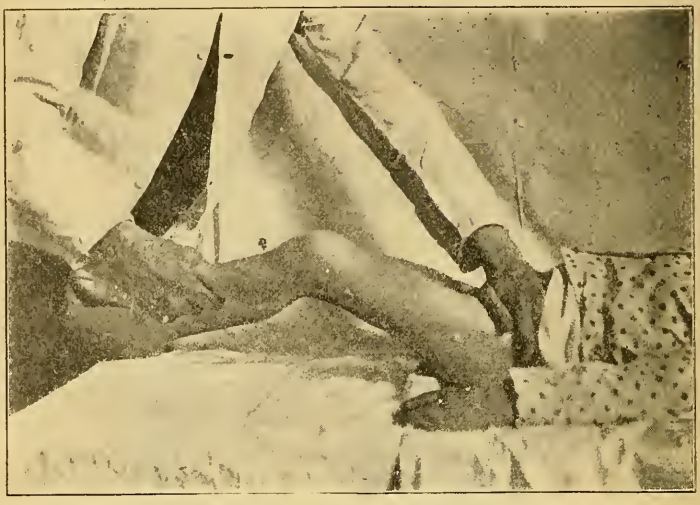

FIG. 208.—Method of Examining Hip.

of motion is not the result of adhesions or beginning ankylosis in early hip disease, but it is the result of a tonic contraction of the muscles con-

FIG. 209.—Method of Determining the Limitation of Extension in Hip Disease.

trolling the joint, and disappears under anæsthesia in the early stages of the disease.

In the detection of this most important diagnostic sign it should be borne in mind that some care is required to discover slight limitation of motion in very young children, who are apt to resist thorough examination. The voluntary resistance to manipulation due to fright is, how-

ever, always resistance to all motions of the limb; if by slight force this is overcome, resistance to any especial motion will not be encountered unless hip disease is present. A comparison of the resistance of one leg with that of the other will reveal abnormal resistance. The normal amount of abduction is, however, slight, and resistance to motion in this direction, therefore, is an early test of importance. Extreme abduction and rotation of the thigh flexed at right angles to the body are delicate tests.

In young and frightened children, the tests for limitation of motion at the hip-joint are best made with the children lying on the mother's lap or leaning on the mother's shoulder. In examining older children for muscular stiffness, the clothes should be removed and the patients should lie upon a hard surface rather than on a bed. Attempts to move the limb should be made gradually, gently, and persistently—rough force only exciting resistance and making a delicate examination impossible. It is advisable first to put the normal leg through the same manipulations which are to be made on the affected side. The most convenient order of motion in examination is first flexion, then abduction and abducting rotation with the thigh flexed, then extension. The suspected limb should be held at the ankle or knee with one hand, while the other hand will grasp the pelvis to ascertain when motion in the joint ceases and movement of the pelvis begins. Examination under anæsthesia shows nothing, at the early stage of hip disease, as muscular spasm, the most important diagnostic sign, has been overcome and is absent.

A limitation to flexion is determined by flexion of the normal limb on the abdomen to its utmost limit, and afterward a repetition of the motion of the suspected limb. If the limb is then extended so that the popliteal space be placed upon the hard surface on which the patient lies, normally there will be no alteration of the position of the back; if, however, there is a limitation in the normal extension of the limb, the back will be arched up as the popliteal space is pressed down. This limitation of extension can also be determined by examining the patient lying upon the belly. If one hand be placed on the sacrum and the thighs be alternately raised from the surface on which the patient lies, a difference in the amount of motion at the hip without moving the sacrum can easily be determined. The limit to the amount of abduction or adduction is determined by placing one hand on the anterior superior spine of the ilium on the sound side, and with the other hand gently abducting or adducting the suspected limb; when limitation is present the pelvis of course moves with the diseased limb. For detecting limitation of rotation the thigh should be flexed to a right angle and rotation tested in that position. The motions most often limited in early hip disease are abduction, extension, and rotation. The loss of motion in this group is always suggestive.

Careful inspection in the early stages of hip disease during manipulation will sometimes show fibrillary contraction of the muscles of the thigh on sudden or unexpected movement of the limb.

In the later stages of hip disease complete stiffness of the joint may be present. This is due to muscular spasm and disappears, in a measure at least, under complete anæsthesia, unless a fibrous ankylosis of the hip joint has begun to develop.

It is not possible to say just what degree of muscular spasm on the part of the muscles can be accepted as evidence of disease of the joint. Any catch in the motion of the joint in any part of its arc is exceedingly suspicious, no matter how slight it may be.

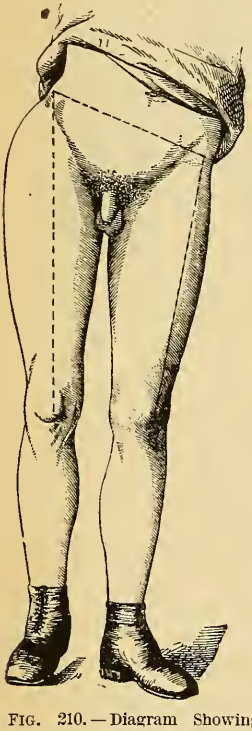

FIG. 210.—Diagram Showing Practical Shortening from Adduction.

Lameness.—At the earliest stages the limping may be intermittent and not constant, and again, it may be so slight that it is practically imperceptible, so that its absence does not exclude hip disease. Its character has been already described, and the fact that it is worse in the morning than at night, but these are not altogether distinctive and the diagnosis cannot be made alone from watching the child walk.

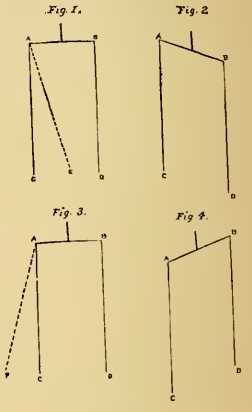

FIG. 211.—Diagram Showing Apparent Shortening and Lengthening of Leg due to Tilting of the Pelvis.

Attitudes. — Abnormal positions of the diseased limb at an early stage of the disease are caused by the action of the muscles holding the limb stiffly in distorted position. Neither adduction or abduction of the limb is usually recognized by the patient as such, but the complaint is made that the limb seems longer or shorter than the other. The pelvis is tilted, which gives a practical lengthening of the limb if abduction is present, and in the same way the limb appears shorter to the patient if adducted. The tilting of the pelvis can be recognized by drawing a line from the anterior superior spine of one side to that of the other. This should normally be at right angles with a line from the umbilicus to the symphysis pubis. In this way have arisen the terms of *apparent or practical*

shortening and lengthening, which have given rise to some obscurity, being often confused with real or bony shortening.

The accompanying diagrams will explain the matter. The normal position of the pelvis in relation to the limbs is shown in heavy lines in Fig. 1, where both legs are at right angles to the pelvis, the normal position for standing and walking. If, however, the right leg is fixed by muscular spasm in an adducted position, *AE*, the relation is changed, and when the patient stands erect the legs must be made parallel to permit walking or standing on both feet, and this can be done only by tilting the pelvis to the position shown in Fig. 2. It will be seen by the tilting that the leg *AC* is carried up with that side of the pelvis and to all appearances the leg *AC* is shorter than the leg *BD*, when the patient stands or lies straight. Thus adduction results in apparent shortening of the adducted limb as compared with the other when the patient lies straight. In the same way in Fig. 3, if the leg *AC* is abducted to the position *AF*, the pelvis must be tilted in the opposite direction to make the legs parallel, because the angle *FAB* is a fixed quantity, and so the pelvis is tilted, and *AC* for practical purposes is longer than *BD*, and the amount of apparent lengthening depends upon the amount of abduction.

A patient then with fixation of one leg in a position of adduction has a deformity which results in a lifting of that leg from the ground when he stands or walks, for the tilting of the pelvis has caused a practical shortening of that leg. In the same way abduction causes the opposite tilting of the pelvis and a practical lenthening of the diseased leg. So that the term apparent or practical shortening can be applied to the inequality of the legs noticed in walking or standing, which results from the tilting of the pelvis. Practical shortening can be estimated by measuring from the umbilicus to each malleolus when the patient lies or stands straight.

Real or bone shortening is different from apparent shortening. It results from the retarded growth or atrophy of the affected limb or from the destruction of bone in the hip-joint, and is independent of the amount of adduction or abduction. Real shortening is measured by a tape from the anterior superior spines of the ilium to the malleolus on each side.

It is important, in an examination for hip disease, to determine the amount of permanent joint injury which the disease has already inflicted. The amount of enlargement of the acetabulum and absorption of the head of the femur which has taken place, may be estimated by determining the amount that the trochanter of the femur has risen above its normal position. If the patient lie upon the well side, and Nélaton's line (from the anterior superior spine to the most prominent part of the tuberosity of the ischium), be drawn over the affected hip, the thigh being somewhat flexed it should pass just above the upper margin of the trochanter; if the trochanter is above this line, it is an evidence of subluxation.

Estimation of Adduction and Abduction.—The amount of deformity due to adduction or abduction or flexion of the limb is an important index of the progress or activity of the disease and should be carefully estimated.

This estimation of the amount of adduction or abduction present has ordinarily been made by the use of the goniometer, an instrument which measures the angle between the transverse axis of the pelvis and the long axis of the leg. The horizontal arm is laid on the anterior superior iliac spines and the other arm is then laid in the line of the diseased leg and the index shows the angle of deformity. This instrument is clumsy and not always at hand. A simpler method has been devised by which it is possible to estimate with the tape measure alone the angle of either abduction or adduction present.

In measuring patients it is found that real and practical shortening of a leg are often not the same in the same patient, and that the difference between them varies in proportion to the amount of deformity present. This was taken as the basis for constructing the following working table. The mathematical process by which it was made is given in full in the original article.[1] To measure by this method, the patient is made to lie straight, with the legs parallel. Real shortening is measured with the ordinary tape measure, and apparent shortening is obtained in the same way. It may be repeated that real or bony shortening is measured from the anterior superior iliac spines to each malleolus, and that practical shortening is found by a measurement taken from the umbilicus to each malleolus. The difference in inches between the two kinds of shortening is seen at a glance. The only additional measurement necessary is the distance between the anterior superior spines, which is taken with the tape. Turning now to the table, if the line which represents the amount of difference in inches between the real and apparent shortening is followed until it intersects the line which represents the pelvic breadth, the angle of deformity will be found in degrees, where they meet. *If the practical shortening is greater than the real shortening, the diseased leg is adducted; if less than real shortening, it is abducted.* Take an example: Length (from anterior superior spine) of right leg, 23; left leg, $22\frac{1}{2}$; length (from umbilicus) of right leg, 25; left leg, 23; real shortening, $\frac{1}{2}$ an inch, apparent shortening 2 inches; difference between real and practical shortening, $1\frac{1}{2}$ inches; pelvic measurement, 7 inches. If we follow the line for $1\frac{1}{2}$ inches until it intersects the line for pelvic breadth of 7 inches, we find 12° to be the angular deformity, as the practical shortening is greater than the real, it is 12° of adduction of the left leg. If apparent lengthening is present its amount should be added to the amount of actual shortening.

[1] R. W. Lovett: Bost. Med. and Surg. Journal, March 8th, 188°

Table I.

Distance between Anterior Superior Spines in inches.

Difference in inches between Real and Apparent Shortening.	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10	11	12	13
¼	5°	4°	4°	3°	3°	2°	2°	2°	2°	2°	2°	2°	2°	1°	1°	1°	1°	1°
½	10	8	7	6	5	5	4	4	4	4	4	4	4	3	3	3	3	2
¾	14	12	11	10	8	8	7	7	6	6	5	5	5	4	4	4	3	3
1	19	17	14	13	11	10	9	9	8	7	7	7	6	6	6	5	5	4
1¼	25	21	18	16	14	13	12	11	10	9	9	8	8	7	7	7	6	6
1½	30	25	22	19	17	15	14	13	12	12	11	10	10	9	9	8	7	7
1¾	36	30	26	23	20	18	17	15	14	13	13	12	11	10	10	9	8	8
2	42	35	30	26	23	21	19	18	16	15	14	14	13	12	12	10	10	9
2¼	..	40	34	30	26	24	21	20	19	17	16	15	14	14	13	12	11	10
2½	..	..	39	34	29	27	24	22	21	19	18	17	16	15	14	13	12	11
2¾	..	..	..	38	32	29	27	25	23	21	20	19	18	17	16	14	13	12
3	..	..	..	42	35	32	29	27	25	23	22	21	19	18	18	16	14	13
3¼	..	..	..	..	39	36	32	30	27	26	25	22	21	20	19	17	15	14
3½	..	..	..	..	..	40	35	33	30	28	26	24	23	22	21	19	17	16
3¾	..	..	..	..	..	..	38	35	32	30	28	26	25	23	22	20	18	17
4	..	..	..	..	..	..	42	38	35	32	30	28	26	25	23	21	19	18

Estimation of Flexion.—The flexion deformity of the thigh may be measured by a similar method.[1] The patient lies upon a table flat on

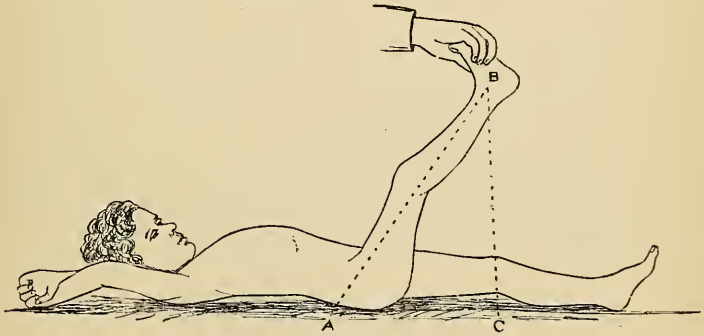

Fig. 212.—Estimation of Flexion.

his back and the surgeon flexes the diseased leg, raising it by the foot until the lumbar vertebræ touch the table, showing that the pelvis is in

[1] G. L. Kingsley: Bost. Med. and Surg. Jour., July 5th, 1888.

the correct position. The leg is then held for a minute at that angle, the knee being extended, while the surgeon measures off two feet on the outside of the leg with a tape measure, one end of which is held on the table (so that the tape measure follows the line of the leg) (AB). From this point on the leg (B) where the two feet reaches by the tape measure one measures perpendicularly to the table (BC), and the number of inches in the line BC can be read as degrees of flexion of the thigh, by consulting Table II. For instance, if the distance between the point on the leg and the table is $12\frac{1}{2}$ inches it represents 31° of flexion deformity of the thigh.

TABLE II.

In.	Deg.	In.	Deg.	In.	Deg.	In.	Deg.
0.5	1	6.5	16	12.5	31	18.5	50
1.0	2	7.0	17	13.0	33	19.0	52
1.5	3	7.5	19	13.5	34	19.5	54
2.0	4	8.0	20	14.0	36	20.0	56
2.5	6	8.5	21	14.5	37	20.5	58
3.0	7	9.0	22	15.0	39	21.0	60
3.5	9	9.5	24	15.5	40	21.5	63
4.0	10	10.0	25	16.0	42	22.0	67
4.5	11	10.5	27	16.5	43	22.5	70
5.0	12	11.0	28	17.0	45	23.0	75
5.5	14	11.5	29	17.5	47	23.5	80
6.0	15	12.0	39	18.0	48	24.0	90

If the leg is so short that it is impracticable to measure off twenty-four inches, one can measure twelve inches; ascertain from here the distance to the surface on which the patient is lying in a perpendicular line in the same way, then doubling this distance and looking in the table as before the amount of flexion is found.

FIG. 213.—Thomas' Test for the Estimation of Flexion of the Diseased Leg in Hip Disease.

Thomas' test for flexion is one which is sometimes of use for a rough estimation of the amount of flexion deformity. The patient lies on the back and the well thigh is flexed on to the abdomen and held there. This places the pelvis in the correct position, with the lumbar spine in contact with the table, and the diseased thigh is by this naturally thrown into a position of flexion if such deformity exists. The figure (Fig. 213.) makes the method plain. It is not suitable for use in cases in which the hip is sensitive, nor, as a rule, in the case of adults.

Atrophy.—Atrophy rapidly becomes more marked than if due to simple disuse.

The measurement for atrophy is made with a tape measure by taking the circumference of both thighs and both calves at the same level on each side. The level at which the circumference is to be taken should be measured from some bony point on both sides, such as the anterior superior spine, the patella, or the malleoli, to insure taking the measurement at exactly the same level. The conventional places for such measurements are at the middle of the thigh and the middle of the calf. The absence of atrophy does not exclude hip disease.

Pain.—Tenderness on jarring the hip is rarely an early symptom. Sensitiveness on slight jar of the hip is sometimes indicated, previous to the presence of conscious pain, by an instinctive wincing on the part of the patient if the limb is jarred. "Night cries" characteristic of hip disease have already been mentioned; they are extremely significant in pointing to the probable existence of serious joint disease. It is no sign of the absence of hip disease when one is able suddenly to jam the head of the femur into the acetabulum without causing pain, a diagnostic method sometimes relied on. Its violence makes it unjustifiable as well as untrustworthy.

Swelling.—In an early stage of hip disease there is, as a rule, no swelling, unless the affection is unusually rapid in its course; the glands in the groin may, however, be found to be enlarged on palpation; while swelling about the hip is not uncommon in the later stage of hip disease. Thickening of the trochanter major is a diagnostic sign of assistance. To recapitulate the important symptoms which establish the diagnosis of hip disease, they are: (1) muscular spasm, (2) lameness, (3) attitude and shortening, (4) atrophy, (5) swelling.

Differential Diagnosis.

A few affections are commonly mistaken for hip disease in practice and deserve notice. These are:

(1) Lumbar Pott's disease. (2) Synovitis of the hip. (3) Infantile paralysis. (4) Congenital dislocation. (5) Hysterical affections. (6) Peri-articular affections.

Other affections can be mistaken for hip disease only through ignorance of its proper symptoms, or at a very early stage before the symptoms have any prominent development.

(1) *Lumbar Pott's disease* may have for its first symptom a limp and a restriction of motion in one leg. This is due to the descent of pus in the psoas muscle or to an irritation and contraction of its fibres. As a rule, this limited motion is only in the direction of loss of hyperextension, but it may take occasionally the form of a general restriction of motion and the joint may be sensitive to manipulation. The point to be determined is whether rigidity of the lumbar spine is present. If so Pott's disease is to be suspected; but sometimes in hip disease at a sensitive stage, the tenderness of the joint is so great that on attempted flexion of the spine the erector spinæ muscles are also spasmodically contracted and lead to the appearance of rigidity of the lumbar spine. The diagnosis may sometimes be a very difficult one, and an opinion must be withheld and the case kept under observation until characteristic symptoms of one affection or the other develop. Later in the history of lumbar Pott's disease a psoas abscess will often descend and may irritate the hip-joint on one or both sides; this may again so closely simulate hip disease that it is hard to tell whether the psoas muscle is causing all the trouble or whether the joint is really involved.

A test of the arc of abduction of the hip may be valuable in this connection, as this motion is impaired or lost at a comparatively early stage of hip disease. It is an excellent rule never to make a diagnosis of hip disease without examining the spine to see if Pott's disease is present.

(2) *Synovitis of the hip* occurs in children, but it presents the symptoms of beginning hip disease and a diagnosis is *not* practicable in the early stages; and the fact that the symptoms occur after a fall must not be allowed much weight as arguing in favor of synovitis.

It is distinguishable from true hip disease only by its relatively briefer course. Acute synovitis begins suddenly, generally after an accident or without known cause, with pain, fever, absolute immobility and local swelling of the hip, the limb being held in a position characteristic of true epiphyseal ostitis. These symptoms may subside gradually with complete recovery of the joint. In synovitis all the usual joint symptoms, such as atrophy, muscular spasm, etc., may be present.

A form of transient or ephemeral affection of the hip[1] will be met in which all the signs of real hip disease are present yet complete recovery occurs in a few months. The pathology of this form of disease is as yet not investigated, but it is probable that in these cases the epiphysis in rapidly growing children is imperfectly ossified and under slight trauma becomes congested, a condition which passes away under rest.

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[1] Boston Med. and Sur. Journal, cxxvii., 161.

In adults, synovitis of the hip may come on clearly after a fall; there is no history of preceding disability, and muscular spasm and wasting are present.

Chronic rheumatoid arthritis, morbus coxæ senilis, which in many cases remains purely a synovitis without ostitis, begins sometimes idiopathically without the history of even slight injury. A diagnostic point relates always to the age at which the patient is attacked, it being practically unknown in childhood, except in extensive cases in which other joints are affected. The presence of rheumatoid arthritis may of course be demonstrated in other joints. Acute rheumatic synovitis of the hip is occasionally seen even in children.

(3) At the stage of onset of *infantile paralysis* there may be for a short time in rare instances marked pain and tenderness, with immobility of one limb; ordinarily these symptoms are not accompanied by other symptoms of hip disease, but are accompanied by loss of power of the rest of the limb as well as a loss of its normal warmth, rapidly followed by atrophy in the whole limb. In the late stages of infantile paralysis there is no stiffness at the hip-joint, but we note abnormal mobility in all directions and other evidences of infantile paralysis, such as distortion of the foot and knee, coldness, atrophy, and marked loss of power of certain muscular groups which make an error in diagnosis very unlikely.

(4) *Congenital Dislocation.*—Congenital dislocation of the hip-joint need not be mistaken for hip disease, as the clinical history of the former is of continued limp since the child commenced walking. The trochanter is above Nélaton's line. There are no symptoms of muscular stiffness or limitation of motion of the hip in congenital dislocation, in fact no symptoms of hip disease except the limp in gait. Patients with congenital dislocation, however, at times have slight attacks of synovitis of the hip due to the imperfect mechanism of the joint, but these symptoms subside after a short rest.

(5) *Hysterical joint affections*, as they are to be diagnosticated from organic joint disease, will be considered more fully under the head of functional joint disease. It may be said here that the symptoms of functional and organic hip disease may be much the same.

Coxa vara need not generally be confounded with hip disease, differing as it does from the latter affection in history and the symptoms of marked stiffness of the joint.

Hip disease is often diagnosticated as "knee trouble," so that it seems worth while to call attention to the well-known fact that hip-joint pain is in most cases referred to the inner side of the knee. Examination will show which affection is present.

Perinephritis and appendicitis have been mistaken for hip disease. Such an error, however, must be rare. In the chronic forms of these affections there may be slight psoas contractions and the presence of iliac

abscesses. In these affections the limitation to motion of the thigh at the hip-joint is not general nor does it affect abduction, but it is most marked in the direction of limitation of extension.

In very rare instances a partial rupture of the adductor muscles may be mistaken for hip disease. It can be distinguished by the history of marked violence and immediate disability, by the tenderness of the adductor muscles, and by the free motion of the hip in the direction of flexion and adduction.

Peri-articular disease, which has not yet attacked the joint or the epiphyses of the joint, is recognized with difficulty. Under the head of peri-articular disease may be included inflammation of bursæ and lymphatic glands, psoas abscess, or psoas muscular spasm from caries of the lumbar spine (psoitis).

Sarcoma of the hip may be mistaken for hip disease or hip disease for sarcoma. The *x*-ray may give assistance in the diagnosis and a piece of the growth should of course be removed for examination.

A separation of the epiphysis of the femur at the hip needs here scarcely more than mention; it is a rare accident occurring only before puberty, and the symptoms are those of intercapsular fracture of the neck of the femur, except that crepitus is not present.

Separation of the epiphysis may occur, as has been said, in hip disease and also in acute arthritis of the hip. It would be recognized by the fact that the trochanter had suddenly become much higher on the affected than on the normal side.

Prognosis.

Under fairly favorable surroundings the disease is one which tends to recovery in a majority of cases with more or less deformity. It is the business of the surgeon to see that the chances of recovery are as favorable as possible, and when recovery occurs that it shall result with the least deformity and the most useful limb possible.

The prognosis of hip disease is to be considered in two aspects: (*a*) the mortality from the disease; (*b*) the functional results to be obtained in the untreated disease and under the different modes of treatment.

(*a*) The rate of the mortality due to the disease in hip disease cannot be accurately estimated. Ultimate results which alone are of value cannot be obtained in hospital practice.

Cazin[1] reported in 80 cases of suppurative hip disease treated at the hospital at Berck, in the course of five years, 55 per cent were cured; 12.5 per cent died; 25 per cent were not cured; 7.5 per cent were improved when removed. Of 288 cases collected by Gibney there was a mortality of 12.5 per cent from exhaustion, meningitis, and amyloid

[1] "Statistique des Coxalgies suppurés," Bull. de la Soc. de Chirurgie, No. 5, 1876.

degeneration. In the Alexandra Hospital, London, there were 100 deaths out of 384, a mortality of 26 per cent; of these, 260 were suppurating cases, and the death rate of these was 33.5 per cent. Forty-two per cent were reported cured. C. F. Taylor, of New York, has reported 94 cases in private practice with only 3 deaths; of these 94, 24 were suppurating. Hueter reports the mortality of hospital cases at 27 per cent, and Billroth at 31 per cent. Jacobson reported a mortality rate of 73.2 in 63 suppurating cases. The mortality rate from the disease alone has been generally considered to be about 30 per cent. Shaffer and Lovett investigated 51 cases of cured hip disease which had been discharged from the New York Orthopedic Dispensary, at least four years previously, and found that 41 had remained cured. Of the remaining 10, 4 had died and 6 had relapsed, although 4 of the latter had been apparently cured a second time.[1]

Causes of Death.—Death may occur from (1) the generalization of tuberculosis in the form of phthisis, tuberculous meningitis, and general tuberculosis. (2) From amyloid degeneration of the viscera. (3) From exhaustion. (4) From intercurrent disease. (5) From septicæmia and exhaustion after suppuration.

In an analysis of cases at the Alexandra Hospital, of 35 deaths the causes were as follows: Meningitis, 12; disease of the lungs, 5; amyloid disease, 9; following amputation, 3; exhaustion, 2; uncertain, 4.

In 96 deaths after suppurative hip disease at the Alexandra Hospital, the causes were as follows:

	Per cent.
Meningitis,	16.7
Albuminuria and dropsy,	20.8
Phthisis,	5.2
Phthisis and albuminuria,	3.1
Exhaustion,	9.4
Erysipelas and pyæmia,	3.1
Intercurrent disease,	7.3
After operation,	9.4
Unknown,	25.0

In a series of 11 deaths recently reported in a series of 150 cases discharged from the Hospital for the Ruptured and Crippled the causes were:

Amyloid degeneration,	5
Phthisis,	3
Tuberculous meningitis,	2
Cardiac disease,	1
	11

[1] N. Y. Medical Journal, May 21st, 1887.

Of 50 deaths known to have occurred in 778 patients with hip disease under treatment at the New York Orthopedic Dispensary the causes were as follows:

Tuberculous meningitis,	20
Amyloid degeneration,	5
Phthisis,	3
Exhaustion,	3
Tuberculous peritonitis,	1
Sepsis,	1
Convulsions,	1
Unknown,	16

(*b*) *Functional Results.*—Spontaneous cure may result in hip disease, but as a rule with little motion and with marked deformity.

In 1878 Gibney[1] reported 80 cases which were cured at the Hospital for the Ruptured and Crippled in New York by internal medication and counter-irritation. Abscesses had existed in 48 cases, and in the other 32 cases there was present no abscess. At the end of the disease (which in 33 cases had run its course in 3 years, in 28 cases in from 3 to 6 years, and in 19 cases in from 6 to 10 years), 61 of these patients could walk well and run without discomfort; 12 walked only fairly, requiring a support at times; and 7 could not walk without crutches. Of these 80 cases, 12 had, at least, an arc of 15 degrees motion in the affected joint, the amount of shortening being, in the majority of cases, from 1 to 3 inches. A recent[2] series of cases from the same institution, investigated by Gibney, Waterman, and Reynolds, is of interest in this connection—150 consecutive cases which had been discharged from the hospital at least five years previous to the investigation. These cases had for the most part been under modern treatment, both mechanical and operative; 107 were cured, 25 were still under treatment, 7 had been recommended to enter the hospital again for the correction of deformity, and 11 had died.

The shortening at the final examination in cured cases was as follows:

None,	21 cases.
$\frac{1}{4}$ inch,	7 "
$\frac{1}{2}$ "	12 "
$\frac{3}{4}$ "	7 "
1 "	24 "
1–2 inches,	22 "
2–3 "	9 "
3–4 "	4 "
6 "	1 "
	107 cases

[1] New York Med. Rec., March 2d, 1878.

[2] Trans. Am. Orth. Assn., vol. xi., p. 256.

The amount of motion in cured cases at the final examination was as follows:

Perfect,	13
Good,	22
Limited,	41
Ankylosis,	31

Shaffer and Lovett[1] published a series of 51 cases treated by the traction splint at the New York Orthopedic Dispensary and Hospital. These patients had all been discharged cured from the institution from 1875 to 1882. The investigation was made in 1886. Only conservative treatment was employed. Of the 41 patients who remained well (out of the 51 discharged cured) no one was incapacitated from doing a full day's work at his or her trade or occupation. Only one, a boy who had suffered from both Pott's disease and hip-joint disease, used a cane, and none used crutches. There were among those who recovered, printers, glaziers, machinists, errand-boys, shop-girls, dressmakers, and many children attending the public schools—all at their work and none with evidences of active tuberculous disease or any serious incapacity arising from the condition for which they were treated years before.

The amount of motion in these cases was:

No motion in joint,	16
Slight motion,	6
10° to 45° of motion,	7
90° of motion,	3
Perfectly free motion,	3

The amount of motion diminished after the cessation of treatment.

If a cure with ankylosis takes place, an important practical point, as regards the use of the limb and locomotion, is the position in which ankylosis occurs. In 15 of the cases alluded to in which there was little or no motion at the articulation, there was no flexion of the thigh. The limp in these cases was trivial. In other cases the thigh was flexed at an angle of 120° to 135° with the horizontal plane of the body. This was not a serious impediment to locomotion when a flexible dorso-lumbar spine and a sound hip-joint on the opposite side existed, but in one case there was caries of the lumbar spine, and in this case there was difficult locomotion. Flexion to 135° with a normal spine does not produce either difficult locomotion or a bad gait, and in no case examined did the permanent flexion exceed this angle.

Permanent *adduction* is a more important matter. Of 24 cases, it was very slight or absent in 13, in 8 it equalled 10° to 15°, and in 3 cases it was about 30°. In 2 cases there was slight abduction of the thigh, and

[1] N. Y. Med. Record, March 2d, 1878.

in one of these there was a condition of hyperextension of the knee. But even in this condition the patient walked well. In cases in which abduction was present in the earlier history of the disease, adduction was found in the late history; and adduction is likely to occur after the removal of the splint, and to increase up to a certain point. But, as shown above, adduction to 30° occurred in only three cases, and in only one of these was it troublesome. In this case with slight flexion, and adduction to 30°, a real shortening of one inch and a half became, for the practical purpose of locomotion, a shortening of four inches.

The shortening was as follows:

Shortening, in Inches.	Cases without Abscess.	Cases with Abscess.
0	2	..
¼	1	1
1	5	5
1½	4	3
2	8	1
2½	5	..
3	..	1
6	..	1
Total	25	12

An investigation was made by Howard Marsh[1] of the results of the conservative treatment of hip disease as practised at the Alexandra Hospital which shows the results to be obtained by mechanical treatment (fixation). Of 37 cases in which suppuration had occurred at the end of one year after discharge—

1 was a perfect recovery.
6 were excellent.
17 were good.
13 were moderate.

3 had no shortening.
17 had under 1 inch.
12 had between 1 and 2 inches.
3 had 2 inches or over.

1 had perfect movement in every direction.
10 had free movement.
7 had slight movement.
18 were fixed.

The 39 cases which did not suppurate went on to still better results. There were—

[1] British Med. Journ., August 3d, 1889.

9 perfect recoveries,
9 excellent "
12 good "
9 moderate "

and the average amount of shortening was two-thirds of an inch, while 50 per cent had what Mr. Marsh classed as "free movement." In all cases the treatment pursued was a bed extension and Thomas splint.

Length of Time for Treatment.—In general the disease does not present the appearance of absolute recovery without probability of relapse in well-marked cases under two or three years of treatment at the shortest, and it is best to continue protection to the joint beyond that time. The following table gives the length of time that the cured cases reported by Shaffer and Lovett were under treatment:

TABLE SHOWING LENGTH OF TIME UNDER TREATMENT.

2 years..... 4 cases.	4 years ..... 8 cases.	6½ years ..... 1 case.
2½ years..... 4 "	4½ years..... 2 "	7 years ..... 1 "
3 years..... 9 "	5 years..... 2 "	8 years ..... 1 "
3½ years..... 6 "	6 years..... 1 case.	

It may be stated that at least from two to three years will probably be needed in the treatment of a case of hip disease taken at an early stage, while protection to the joint will be advisable for two or three years more.

The early discontinuance of treatment is a serious mistake, as relapses are likely to occur when everything seems quiet. Again and again it has been the experience of the writers to change to a convalescent splint in cases in which the symptoms had been thoroughly quiescent for months and the change has been followed by a relapse within a few weeks. In the same way too early a discontinuance of the convalescent splint will often cause trouble. It is therefore much safer to err on the side of keeping on an apparatus unnecessarily long than to run what would seem to be a considerable risk of relapse. Even when a relapse does not occur, the too early discontinuance of treatment may lead to an increase in the flexion or adduction deformity.

Muscular fixation, or muscular rigidity, diminishes as the disease improves and motion returns to the diseased joint. It may return entirely and the presence or absence of abscess does not affect the outlook in that regard, as shown in the Orthopedic Dispensary series.

The prognosis as to distortion, however, does not necessarily imply permanent distortion; for at the present time, after recovery from hip disease (the deformity still existing with severe flexion and adduction) these disfigurements can be entirely and permanently relieved by sub-

trochanteric osteotomy. In short, by far the greater number of cases of this distortion can be prevented by ordinary care and thorough treatment. If they continue after the disease at the hip is cured, the deformities can be overcome with but slight risk, by means of operative interference. It is, however, much more desirable to correct malposition of the limb whenever it occurs than to allow it to become permanent when its correction is a much more serious matter. The prognosis as to lameness has already been alluded to in speaking of the amount of malposition of the limb.

Some *shortening* will be present in a majority of cases if the disease continues for any time; but for practical use in locomotion the actual shortening is of much less moment than the position of the limb.

In the Orthopedic Dispensary series the difference in the length of the legs, measured from the anterior superior spine of the ilium to the inner malleolus, was, when any difference existed, from half an inch to two inches and a half, with two exceptions. One patient, with dislocation of the head of the femur, had six inches shortening, and one (without abscess) had three inches. Two had absolutely no shortening. The case with six inches shortening and dislocation ran its entire course without evidences of suppuration, while, on the other hand, the patients in whom there was absolutely no shortening each had abscesses.

In general, the cases with suppuration showed hardly more shortening than cases without abscess. The same point was elaborated by Hibbs more fully in a series of one hundred and six cases at least two years under treatment at the same institution. His conclusion from this investigation was that "there is no reason to expect greater shortening in cases which have suppuration than in those that have not."[1]

Actual shortening due to arrest of growth of the limb is beyond the control of the surgeon; but shortening from subluxation or dislocation of the head of the femur or enlargement of the acetabulum may be said to be due to a lack of thoroughness of treatment by traction. Perfect treatment may in some instances be impossible, from circumstances beyond the control of the surgeon; but he should persistently bear in mind that subluxation and distortion can be prevented by thorough treatment of the disease.

Atrophy is never entirely cured, but in the calf muscles it diminishes very much after the use of the leg is resumed.

The significance of *abscess* is not very great; it has been seen that it does not affect the ultimate amount of motion in the joint nor does it seriously increase the shortening. The following table from the Orthopedic Hospital series will show that the presence of abscess not only did not prevent a cure, but in two cases a cure took place with perfect motion at the joint:

[1] R. A. Hibbs: N. Y. Med. Journ., November 5th, 1898.

TABLE SHOWING THE INFLUENCE OF THE PRESENCE OR ABSENCE OF ABSCESS UPON JOINT-MOTION.

Condition of Joint as regards Motion.	One or More Abscesses.	No Abscess.	Total.
No motion in joint	12	4	16
Slight motion	4	2	6
10° to 45° of motion	5	2	7
90° of motion	3	..	3
Perfectly free motion	2	1	3

When abscesses occur in cases under careful mechanical treatment, the outlook is worse than in suppurative hip disease in general, because the careful treatment prevents the occurrence of abscess in all but the worst cases, so that in these the death rate is necessarily high. In a series of 63 cases of abscess from the Boston Children's Hospital[1] the death rate was 40 per cent. Abscess occurred in 18.7 per cent of 574 cases of hip disease under out-patient treatment which were analyzed,[2] whereas the earlier Alexandra reports gave 70 per cent of abscesses; if, therefore, abscess appears in spite of careful treatment and preventive measures its prognostic import is most unfavorable. The spontaneous closure of sinuses of long duration is a favorable prognostic sign.

The amount of sensitiveness of the hip and pain in cases which are well treated should be slight, though nocturnal cries may persist for a while in the early stages. The re-occurrence of night cries late in the disease, or of acute sensitiveness of the joint, is most often a sign of inadequate treatment or of trouble coming in the joint; most frequently it precedes the occurrence of abscess.

Under conservative treatment *carried out for a sufficient time* one may expect a good functional result in the majority of cases. In few diseases is the benefit of thorough, skilled, and long-continued treatment more clear, and in few surgical affections can the surgeon attempt to check the progress of disease and influence recovery with greater probability of success than in hip disease; but the surgical care and supervision should not be limited to the more acute stages of the affection, but should be continued during the convalescent stage if the best results are desired.

The report of a few representative cases may serve to make the matter of prognosis somewhat plainer than it is possible to do by the analysis of large groups of cases. These cases are taken from the records of the Children's Hospital, and the patients were under the care of various surgeons on service at the hospital, all, however, carrying out treatment by more or less efficient traction during the requisite stages. They were

[1] Boston Med. and Surg. Journ., November 21st, 1889, p. 503.

[2] Lovett: "Dis. of Hip," p. 117.

not continuously, and in some cases not at all, under the personal care of the writers. They represent cases in which, from the history of the results, there could be no doubt as to the existence of well-marked disease at the joint, and are selected because of this fact. They are all hospital cases with treatment at their homes under the direction of the out-patient department as well as in the wards of the hospital during the acute stages when necessary. They do not represent the best results which can be obtained under more thorough nursing, under the direction of a trained nurse or an intelligent mother in exceptional cases. They are hospital cases treated in a routine way. They are intended to illustrate the fact that in cases thoroughly and properly treated by traction subluxation can be prevented; that in cases of the severer types, if treated early, some motion of the hip-joint can be preserved; and that in the less severe cases, or cases in which prompt and early treatment was possible, motion can be expected.

In the cases here reported the diagnosis of hip disease was certain. All cases were rejected in which the evidence of hip disease was doubted, both from the records and from the statements of the examiners. The record of motion is also without doubt in the cases where it is recorded, as it was made with particular care, and all cases were rejected in which there was any doubt. The motion was tested by placing the patient on the back, with one hand upon the pelvis, the other manipulating the thigh. The examination, diagnosis, and subsequent observation were made by experienced observers. The cases had all been under observation for a long period.

The cases may be grouped: First, as those of hip disease of a severe type, as proved by the development of abscess or the arrest of growth; second, cases without abscess, but with persistent spasm, limitation of motion, and deformity, and a long period of pain and sensitiveness; third, the lighter form of disease treated before the severe symptoms had been developed. These cases may be regarded as representative ones seen in the clinic at the Children's Hospital where continued treatment was carefully carried out.

Cases of Severer Type.

Case I.—Annie F. entered the out-patient department of the hospital in February, 1888, being at that time fifteen years old. The disease had been in progress for two years, one of which had been spent in bed. Pain had been severe and night cries frequent. An abscess had formed, and the joint was flexed and fixed. Traction treatment was begun and continued for two years with traction splint and crutches. A protection splint was worn for four years more.

Condition, 1894.—Twenty-one years old; strong, healthy woman; weight, one hundred and twenty-one pounds. The sinus has been healed three years. There is motion in flexion of ten degrees at the hip-joint. There is no motion in other directions. Patient walks well. There is a three-inch shortening, but the trochanter is not above Nélaton's line. There is no deformity.

Case II.—Nellie M. entered out-patient department of the hospital, September, 1884, when eleven years of age. The disease had lasted for three years. There had been much pain, and the patient had been treated by high shoe and crutches. Abscesses had been present and a sinus remained. Persistent muscular spasm and pain. Traction treatment was carried out, and a traction splint worn for three years and a

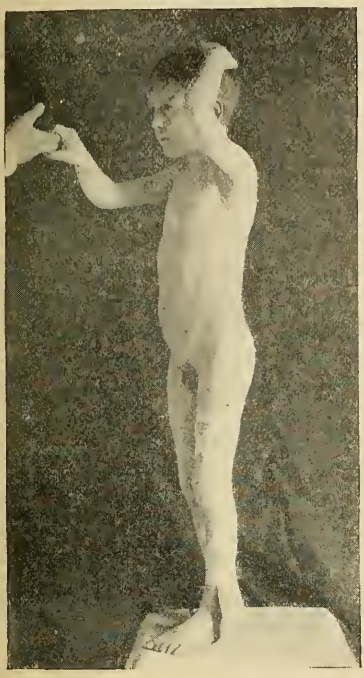

Fig. 214.

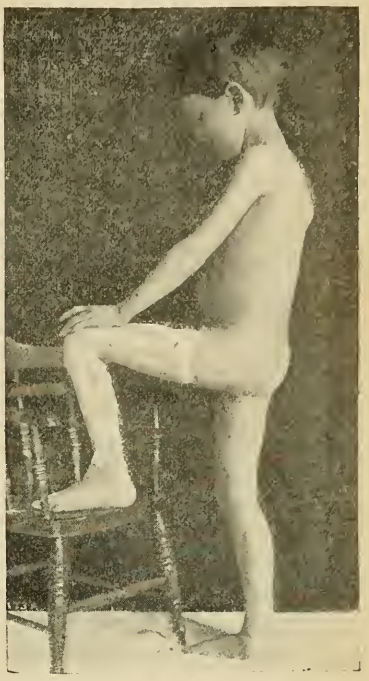

Fig. 215.

Figs. 214 and 215.—A Case of Hip Disease under Ambulatory Treatment. Result good. Motion to right angle. (Children's Hospital Report.)

half; after this a protection appliance was worn and is still worn, although no symptoms have been present for a long time.

Condition, 1894.—Twenty-one years of age, strong and healthy. Walks firmly without splint, but with a limp. The trochanter is below Nélaton's line. There is shortening of two inches from difference in growth. Motion of the joint limited except in flexion; 35° of motion in flexion.

Case III.—George K. entered the out-patient department of the hospital in March, 1887, when fifteen and a half years old. The disease had existed for four months. Traction splint was applied. The hip became sensitive, and an abscess appeared the following year. Muscular spasm lasted for two and a half years. Traction was continued for three years, and a protection splint worn four years longer.

Condition, 1894.—Twenty-two years old; healthy, strong man, walking without a splint. There is an inch and a half shortening of the leg, but no subluxation, the trochanter being below Nélaton's line. The position of the leg is normal. There is no motion.

Case IV.—Hattie H. came to the out-patient department of the hospital in March, 1886, when five years old. Disease was of six months' duration. The leg was flexed to an angle of forty-five degrees. There were much pain and sensitiveness.

The muscular spasm continued for nearly two years, and an abscess followed. Traction treatment was carried out for two years, a traction splint being worn a good portion of the time. A protection splint was used for three years more.

Condition, 1894.—At the age of thirteen the child is strong and well. The tro-

FIG. 216.

FIG. 217.

FIGS. 216 and 217.—A Case of Hip Disease under Ambulatory Treatment. Result fair. Motion to 45°. (Children's Hospital Report.)

chanter is below Nélaton's line. There is a shortening of half an inch. Flexion of ninety degrees is possible. Walks without a limp. There is no deformity.

CASES OF THE SECOND CLASS.

CASE V.—Sophie R. entered the out-patient department of the hospital in January, 1886, when six years of age. The disease had lasted for nine months and the hip was fixed. There was pain, and the spasm lasted for two years. Treatment by traction was carried out for three years and by protection for two years more. No abscess occurred.

Condition.—January, 1893, there was half an inch shortening. Flexion was possible to a right angle. Rotation and abduction limited.

CASE VII.—Robert H. was brought to the hospital in March, 1888, when four years old. The disease had lasted about two months. There was much muscular spasm at the hip, with marked pain, which persisted for some time, with swelling about the hip. Bed treatment was carried out for a month. The muscular spasm improved after six months, but remained for two years. Traction treatment was applied during all that time, and a traction splint worn while the patient was up. A protection splint was worn for two years more.

Condition, 1894.—At the age of ten the patient walks without a limp. There is a shortening of half an inch in the affected limb, but no deformity. Motion is possible to ninety degrees in flexion; rotation is limited.

Case VIII.—Esther M. came to the out-patient department of the hospital in 1888, when eight years old. Disease had lasted for six months. The hip flexed and adducted. Pain was severe. No motion at the hip-joint was possible. Pain and sensitiveness were marked and bed treatment was necessary. Treatment by traction was carried out for three years, and protection for three years more. Protection splint is still worn as a precaution.

Condition, 1894.—The patient is fourteen years of age, strong and well, and can walk without a splint. Forty-five degrees of motion is possible in the direction of flexion. There is an inch and a half of shortening, but the trochanter is not above Nélaton's line. There is no deformity.

Case X.—Anastasia H. entered the hospital in 1886, when five years old. Disease had been in progress for several months. Night cries had been noticed for three months. Admission to hospital for bed treatment. Patient remained in hospital three months. There was no abscess. Spasm continued for two years. There were pain and persistent adduction. Traction treatment carried out for two years and a half; protection for a year and a half longer.

Fig. 218.—A Case of Hip Disease under Ambulatory Treatment. Result bad. No motion, discharging sinuses, shortening and atrophy. (Children's Hospital Report.)

Condition, 1894.—Thirteen years old; girl is strong and well, walks without a splint, and with no perceptible limp. There is an inch shortening, but no deformity. Motion of ninety degrees possible, but limitation in other motions. (Figs. 219, 220.)

Cases Treated at an Early Stage.

Case XII.—James G. entered the out-patient department of the hospital in April, 1890, with a history of pain in the knee at night for several weeks. Pain continued for some time. Limitation of motion. There was, however, but little muscular spasm. A traction splint was applied and worn continuously for two years. In August, 1892, a protection splint was applied and has been worn since that date.

Condition, 1894.—The position of the leg at present is normal. There is no shortening. Motion beyond ninety degrees. There is no muscular spasm.

The diagnosis in this case is based upon the pain which persisted, the limitation of motion, and the length of time which the muscular spasm persisted. (Figs. 221 and 222.)

Case XIII.—Eva C. The patient entered the out-patient department of the hospital November, 1891. There was severe pain, with night cries, muscular spasm,

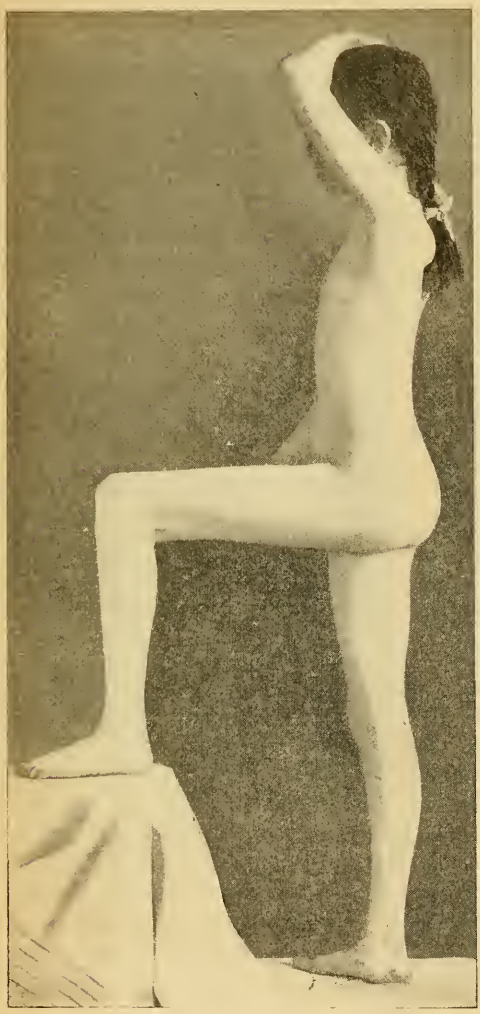

Fig. 219.

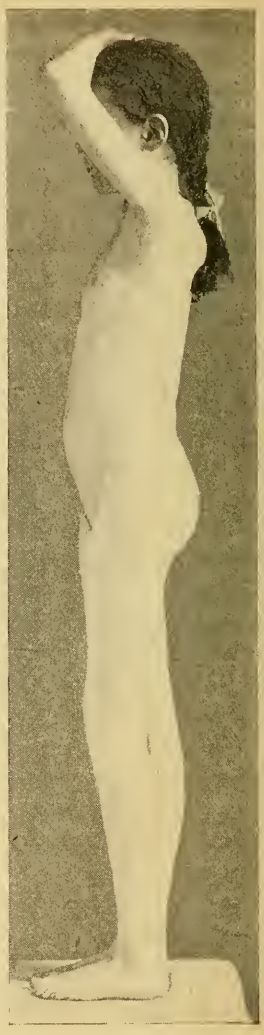

Fig. 220.

Figs. 219 and 220.—Patient, Thirteen Years Old. Traction treatment, two and one-half years. Protection, one and one-half years. End result.

and deformity, and these symptoms had persisted for several weeks. The patient entered the wards of the hospital and remained in bed with traction treatment for six weeks. A traction splint was worn for a year and then removed by the parents, the child being considered by them in perfect health. The child was allowed to use the leg freely, and a relapse occurred after six months, with pain, night cries, spasm, and deformity. Traction treatment was renewed after a preliminary bed treatment with fixation and traction.

Condition, 1894.—At the present time, three years and a half after commencement of treatment, there are slight permanent flexion and free motion of twenty de-

FIG. 221.—End Result in Patient with Hip Disease under Traction Treatment. Traction two and one-half years. Trochanter on Nélaton's line.

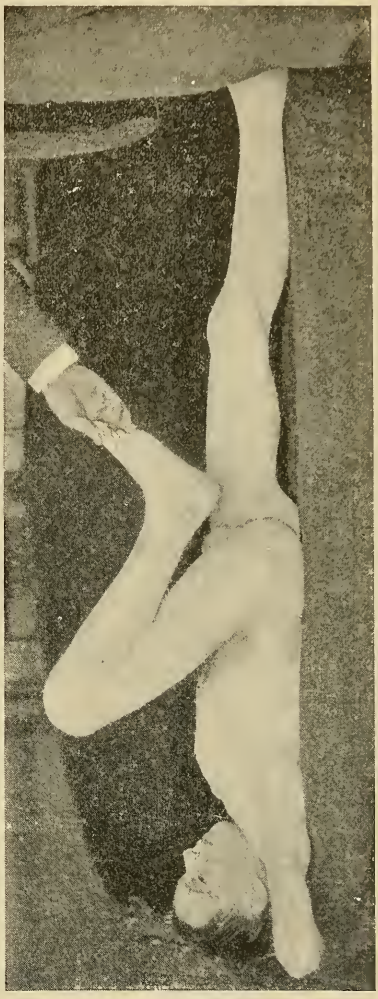

FIG. 222.—End Result in Patient with Hip Disease under Traction Treatment. Traction two and one-half years. Trochanter on Nélaton's line.

grees. There are no subluxation and no shortening. Patient still wears a traction apparatus.

This case is reported as indicating a lack of perfect result. Treatment was discontinued by parents for several months and a relapse occurred.

The case is still under observation, but the ultimate result, which could in all probability have been without limp. will be with a slight limp.

Treatment.

The treatment of so chronic an affection as hip disease necessarily varies with the different indications and may be likened to a long campaign in which various expedients will be needed. No one method will suffice, but the varying pathological conditions—acute destruction, chronic cicatrizing ostitis, periarticular inflammation, muscular spasm, and distortion—must be met by the rational employment of the best counteracting measures. It is to be remembered that the hip-joint differs from the other joints in that it is surrounded by strong muscles. These, in case of acute inflammation of the joint, develop a condition of exaggerated irritability analogous to the blepharospasm in ulceration of the cornea. This condition needs surgical consideration, as unless checked it will develop deformity and destruction of the joint. The means at the surgeon's disposal besides operative measures may be classed as means of fixing the joint and protecting it from injury. These vary as the patient is confined to bed or allowed locomotion (the latter, except for a relatively short period, being essential to the establishment of complete tissue repair without which no cure is complete). The complications which are met are periarticular abscess, deformity, and extensive necrosis.

It is manifest that in so formidable an affection as hip disease the most thorough measures are necessary, especially during the stage of acute inflammation.

Clinical experience as well as theoretical reasoning demonstrates that it is impossible thoroughly to protect a hip-joint when in an acutely inflamed condition without preventing movement at the joint on the part of the patient, and counteracting the increased pressure of the femur against the acetabulum due to exaggerated muscular contraction.

As the employment of traction in hip disease is not universal, nor when used always applied with sufficient thoroughness, it is desirable that the exact effect of traction on the hip be studied.

No argument will be needed to demonstrate the fact that a certain amount of traction can be applied to the femur in hip disease. A number of experiments have been made to determine the direction and amount of traction force which is feasible and which can be worn continuously. The details of these experiments will not be given here, but it will be stated that the limit of traction has been found to be the limit of the skin to endure the strain of the adhesive-plaster pull. This amount can be placed at from ten to twenty pounds. It therefore remains to determine what is the effect of the traction force of from six to twenty pounds upon a hip-joint affected by hip disease. To determine this, observations were made by the writers, first, on the cadavera of healthy hips; second, on

the cadavera of diseased hips; third, on healthy individuals; and on patients suffering from hip disease.

1. *Normal Joints.*—The hip of a full-term infant was prepared in such a way that the skin was removed so as to expose the muscles around the hip. It was found that under a slight amount of traction, distraction was possible. This was not only visible to the eye, but it was also demonstrable on a specimen on which the skin was removed without disturbing the ligaments or muscles. A needle was inserted in the head of the femur and another in the ilium slightly above the acetabulum, a slight amount of force separating the two needles.

An adult dissecting-room specimen was taken, the femur amputated below the trochanter, and the pelvis fixed. The skin was not removed and a traction force was applied. Needles were inserted into the femur and into the ilium, the skin and muscles being incised in such a way that the traction force would not disturb their relative position. Traction of a hundred pounds was applied, and it was found that the needles were separated an eighth of an inch. After the specimen had been soaked in weak alcohol for some time distraction of an eighth of an inch was easily effected by a pull of five pounds.

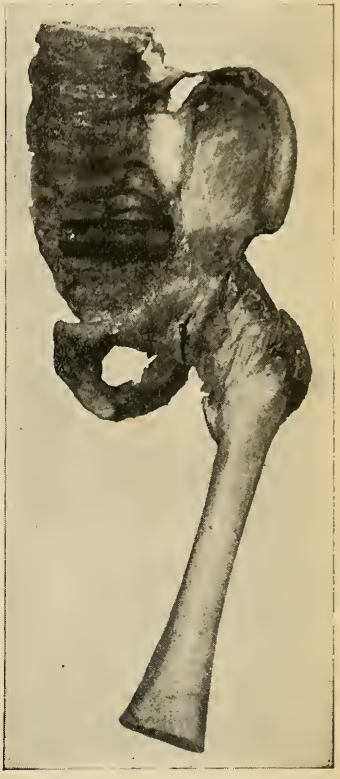

FIG. 223.—Specimen Showing Distraction of the Hip in a Child.

On a large amount of material placed at the disposal of the writers by Professor Dwight, of Harvard University, it was clearly shown that traction distracted in all cases of femora in children dissected or undissected, and in all specimens of infants, and that the checks to distraction in adult cadavera lay in the resistance, first, of the capsular ligament, especially of the anterior bands of the ilio-femoral ligament; second, in the resistance of the cotyloid ligament, and to a slight degree in atmospheric pressure. In children the lower edge of the acetabulum presents no resistance to a traction in the line of the axis of the body. (Fig. 223.) In adults this presents a resistance, but if the limb is abducted the resistance is avoided. Both in children and in adults, if the femur is extended to its utmost limit, the anterior bands of the ilio-femoral liga-

ment lying on the front of the capsule prevent all distraction on any force which it is feasible to apply. If the capsule and cotyloid ligaments are disorganized, distraction is easy.

2. *Diseased Joints.*—In a specimen of a case of hip disease of six months' duration, in which death took place from scarlet fever, it was found that distraction was easily made by the slightest traction. In this specimen the cotyloid ligament was disorganized, but the strong ligamentous fibres of the capsular ligament alone served as a check to separation of more than half an inch on traction. But within that limit even the weight of the pendant fragment of the femur distracted.

3. *Measurements upon Living Subjects.* —Experiments upon living subjects demonstrate that traction distracts under certain circumstances. A number of experiments have been made on the subject of traction by several observers.[1] Brackett demonstrated that in certain cases in hip disease distraction resulted from traction. The following observations have been made with much care to produce further evidence. Measurements were made in traction both in health and in disease. The experiments here reported were made at the Children's Hospital, and the writers are indebted to Dr. John Dane for the perfection of the method by which the experiments were carried out.

The method of experiment was as follows: The patient was placed upon a hard table with the head against the wall, and perineal straps upon each side were secured to the head of the table by stout webbing. In some instances shoulder straps of a similar character were also added. This was for the purpose of preventing the child from slipping on the table as far as possible. All measurements were taken from the wall. Measurements at different points were taken by different observers. The anterior superior spine was marked with a hair line in ink on both sides, and in some of the experiments the great trochanter was marked as well. A mark was also made at the site of the external malleolus. A tape was carried from the wall touching these marks on the side experimented upon, and on the other side it was carried to the anterior superior spine to show any tilting of the pelvis which might occur. Traction on the leg was made by means of webbing straps fastened to a lacing which did not go below the knee. Traction, therefore, was made wholly upon the thigh. Traction was made by means of a spring balance fastened to the webbing straps below the foot. In each experiment traction was first made of ten pounds; then of twenty pounds. To prevent any error

[1] Koenig, Paschen, and Morosoff, quoted by Lannelongue: "Coxotuberculose," Paris, 1886; Deutsch. Zeit. für Chir., 1873, iii., 256; Bull. et Mém. de la Soc. de Chir., 1886, xii., 31; Boston Med. and Surg. Jour., 1880, ciii., 65, and August 30th, 1888; Brackett: Trans. of the Am. Orthop. Assn., vol. ii.; also, Trans of the Am. Orthop. Assn., vol. vi., p. 127; Bradford & Lovett: Children's Hospital Report, 1895.

caused by the slipping of the skin around the sole of the foot, a plaster-of-Paris bandage or a stout cotton bandage was applied from the toes to the knee, and upon this bandage the site of the external malleolus was marked. The heel was made to slide upon a glass plate to avoid friction. In making the experiments any case in which the heel left the plate during the traction, was thrown out as inaccurate. The experiment was made as follows:

An observer was detailed to watch the mark made over the anterior superior spine; another observer was detailed to notice the mark at the external malleolus; a third noted the anterior superior spine on the well side, and in some of the earlier experiments, to check the correctness of the method, independent observers were placed either at the knee or at the great trochanter. In most instances three observers were employed, one at the anterior superior spine, one at the external malleolus on the diseased side, and the other at the anterior superior spine on the well side.

The patient was placed upon the table as prepared, and each observer read the position that the line marked with ink upon the part of the patient he was to watch measured on the tape. Traction of ten pounds was made. Each observer noted the position under the new conditions, and they were put down by the recorder. Traction of twenty pounds was made, and each observer noted the position of the line on the tape. These were also noted by the recorder. In every experiment, unless otherwise stated, the experiment was immediately verified with the observers changed. The method of observation, in short, was to measure the distance of the external malleolus from the wall; knowing the distance of the anterior superior spine, to make traction upon the leg, and see how much the external malleolus had descended; then, noting how much the anterior superior spine had been pulled down, to find the amount of separation between the external malleolus and the anterior superior spine, this giving the amount of distraction of the hip-joint surfaces. The method of these experiments has been related in detail because upon its accuracy the value of these experiments depends.

Various sources of error were eliminated. The fact that traction was made upon the thigh alone eliminates any source of error from stretching of the knee-joint ligaments.

An error due to the stretching of the skin may be disregarded in these observations. The skin of the thigh is pulled down, but the skin of the leg is not pulled upon. Consequently, any such stretching would tend to show less lengthening than really occurred.

In these experiments traction was made in the line of the body, and, unless otherwise stated, the amount of malposition present was not enough to be noted.

As evidence of accuracy of these measurements it is to be remembered:

1. At the time of the experiment the observers were entirely ignorant of its result.

2. The error caused by the slipping of the skin tends to diminish the amount of distraction as shown by these experiments.

3. The experiments agree with each other and with those of other observers.

Observations on Healthy Joints.—The first experiment was of special interest. A girl of seven, with dorso-lumbar Pott's disease, had an abscess which pointed at the outer side of the thigh. This was opened by an incision of three inches, exposing the trochanter. The hip-joint was healthy. Some days after operation the girl was laid upon a table, secured in place, and an upright was erected upon the table with the needle pointing at a marked spot on the exposed trochanter. Ten pounds of traction produced no measurable effect; traction of twenty pounds produced distraction of a quarter of an inch, as seen by the mark on the trochanter as compared with the fixed point adjacent—*i.e.*, the needle. If traction of twenty pounds was made, the head of the trochanter could be seen to descend; if traction was suddenly relaxed, the head of the femur could be seen to move upward.

TRACTION IN HEALTH.

Case No.	Sex.	Age.	Condition.	Traction in Pounds.	Result in Inches.	
1	Male.	6 years.	Hip disease on other side.	10	⅛ lengthening.	Verified by change of observers on repeated experiment.
			Healthy hip examined.	20	¼ lengthening.	
2	Male.	7 years.	Hip disease on other side.	10	¼ lengthening.	Verified by change of observers on repeated experiment.
			Healthy hip examined.	20	¼ lengthening	
3	Female	7 years.	Healthy hip examined.	10	⅛ lengthening.	Not verified.
			Hip disease on other side.	20	⅛ lengthening.	
4	Male.	7 years.	Healthy.	10	⅛ shortening.	Verified by change of observers.
				20	½ lengthening.	
5	Male.	10 years.	Healthy hip examined.	10	⅛ lengthening.	Verified by change of observers.
			Hip disease on other side.	20	¼ lengthening.	
6	Male.	12 years.	Two observations on healthy hip:			
			First experiment.....	10	No change.	Verified by change of observers.
				20	No change.	
			Second experiment...	10	No change.	Verified by change of observers.
				20	⅛ lengthening.	
7	Male.	16 years.	Healthy hip examined.			
			Hip disease on other side.			
			First experiment.....	10	No change.	Verified by change of observers.
				20	⅛ shortening.	
			Second experiment...	10	No change.	Verified four times.
				20	⅛ shortening.	

The fourth experiment is of interest, as it was done upon a young and particularly well-developed girl without any disease. Traction of ten pounds, instead of causing lengthening, caused an eighth of an inch shortening.

The seventh experiment, which was done upon a young man sixteen years old, was of the same character. Traction of ten pounds produced

no effect, but traction of twenty pounds produced an eighth of an inch shortening. This was verified four times with all the observers changed, and the result in each case was the same. It is not easy to explain this phenomenon. Possibly in these cases the amount of traction applied stimulated the healthy muscles to contraction, which vitiated the measurement by altering the axis of the leg. In the fourth experiment twenty pounds altered this and produced a half-inch lengthening in a boy of seven years of age. It seems probable that in the seventh experiment, in which the boy was sixteen years old, a larger amount of traction than twenty pounds would have produced a lengthening.

Observations upon Diseased Joints.—The experiments in general need no comment, except that it is interesting to note that in Experiment 8 the child had never had traction applied before, and in that case the largest amount of distraction occurred. That is to say, it seemed as if in the other cases in which traction treatment had been used a certain amount of previous stretching of the muscles might have existed. In Experiment 12 traction of twenty pounds seemed to be insufficient to cause separation of the joint surfaces, the disease having persisted some time.

TRACTION IN DISEASE.

Case Number.	Sex.	Age, Years.	Length of Disease.	Character of Disease.	Amount of Traction in Pounds.	Result in Inches.	
1	M.	5	7 months.....	Acute.....	10	No change.	Verified.
					20	¼ lengthening.	
2	F.	5	3 months.....	Acute and sensitive.....	10	¼ lengthening.	Not verified on account of pain.
					20	½ lengthening.	
3	M.	4½	1 year.....	Quiescent; fifteen degrees of motion.	10	No change.	Verified with different observers.
					20	⅛ lengthening.	
4	F.	6	3 years; sinuses.	Acute; no malposition; few degrees of motion.	10	⅛ lengthening.	Not verified.
					20	¼ lengthening.	
5	M.	6	2¼ years.....	Convalescent; old abscesses.	10	¼ lengthening.	Verified.
					20	⅜ lengthening.	
6	M.	7	3 years.....	Very sensitive; abscess, spasm, slightly abducted.	10	⅜ lengthening.	Verified.
					20	⅜ lengthening.	
7	M.	7	3 months.....	Acute; some motion.....	10	⅛ lengthening.	Verified.
					20	¼ lengthening.	
8	F.	8	1 year.....	Acute and spasm; not very painful.	10	¼ lengthening.	Verified. Never had traction applied before.
					20	⅝ lengthening.	
9	M.	10	3 years.....	Moderately sensitive; very little motion.	10	No change.	Verified.
					20	⅛ lengthening.	
10	M.	10	3 years.....	Not sensitive; forty-five degrees of motion.	10	¼ lengthening.	Verified.
					20	⅜ lengthening.	
11	M.	12½	3½ years.....	Convalescent; good motion.	10	⅛ lengthening.	Verified.
					20	¼ lengthening.	
12	M.	16	Indefinite: over a year.	Forty-five degrees of motion.	10	No change.	Verified.
					20	No change.	

The conclusions which can be drawn from this table seem to be the following: That traction of ten pounds in children before puberty as a rule produces lengthening of the leg in hip disease, and that this lengthening is due to separation of the joint surfaces; that the amount of this separation varies in different instances, being in general less in older children than in young ones, and also varying in individual cases

under apparently the same conditions, perhaps on account of some anatomical peculiarity; that twenty pounds traction, as a rule, produces more separation than ten pounds.

It is probable that in the later cases of hip disease, in which cicatrization of the capsular tissue may be supposed to have taken place, distraction is not so readily made.

FIG. 224.—Hip-joint from Boy, Nine Years Old. Hip disease had existed six years previously and had been treated by traction. Death from meningitis. Specimen shows no widening of acetabulum, and but little alteration in the head of the femur.

It remains, for the complete demonstration of the proposition presented, to show the effect upon the diseased joint if traction is efficiently applied for a long period. This can be done by pathological specimens as well as by clinical facts.

The effects of traction, when thoroughly carried out, can be seen in the specimens shown in the figures.

The first is that of a boy of nine, who was attacked with hip disease of an acute form six years before. He was treated with traction efficiently for a long time, first with recumbent fixation, later with an ambulatory traction splint and crutches, and afterward by a protection splint. An abscess developed in the early stages, was incised, and it subsequently healed entirely. The boy recovered completely after a number of years from hip disease, having, however, a limb which was slightly shorter (an inch and a half) than the other and with limited motion. The position was good, and the leg was thoroughly useful and remained so two years after the discontinuance of all treatment, the boy being as active as any boy at this time. He was, however, subsequently seized with tuberculous meningitis, being of a tuberculous family, and died. At the autopsy complete cure of the hip disease was found, and the specimen (Fig. 224) also shows that there has been no widening of the acetabulum, and but little alteration in the shape either of the acetabulum or of the head of the femur.

A comparison of this specimen with those of severe hip disease in which traction was not used speaks most emphatically for the thorough use of the method.

The specimen shown in Fig. 226 is of the head and neck of the femur in which, after two or three years of efficient treatment by traction, the reparative process was not sufficient to establish a cure; the patient's general condition failed, and excision was done. It is to be noticed that there is very little alteration in the shape of the head of the excised femur. This, compared with the accompanying specimen (Fig. 225) of an excision in a patient with hip disease of similar severity and duration

FIG. 225. FIG. 226.

FIG. 225.—Specimen from Excision of Hip when Traction had not been Employed. Severity and duration of disease similar to that of case in Fig. 226.

FIG. 226.—Specimen from Excision of Hip Treated by Efficient Traction for Three Years. Operation done because of failure in general condition.

in which no traction had been applied, would appear fairly to show the effect of traction in saving the head of the femur from destruction.

It cannot be supposed that the best results can be obtained by the application of inefficient traction. A sufficient amount of traction, constantly applied during the stage of muscular spasm, is needed. It is, of course, not the only therapeutic measure which is required; fixation and protection are also needed at the various stages. If traction is not applied properly, or is applied at the wrong time, or is insufficient in extent, it is no more efficient than a drug injudiciously or wrongly used or administered at the wrong time. Judgment is required in the use of this measure as of any other, and a great deal of care and attention to detail is necessary to insure the constant application of from eight to ten or fifteen pounds' traction uninterruptedly for two or three or six months, not only on the part of the surgeon, but on the part of the nurses and

assistants. It is owing to the defect in this respect that in many cases treatment by traction is ineffectual, and the results obtained are not so

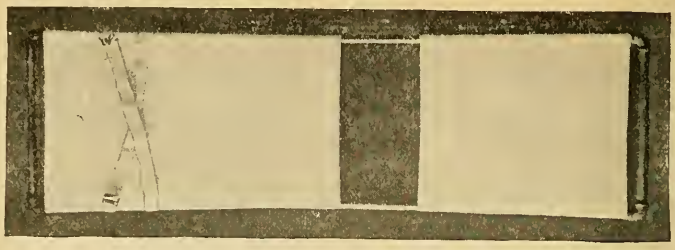

FIG. 227.—Gas-Pipe Frame. (Children's Hospital Report.)

satisfactory as desired. This leads to an unjust condemnation of the methods of treatment by traction by those who have tried this method, and, having met with unsuccessful results, have blamed not their own method of application, but the method in general, which is as irrational as if any one who administered a drug in an insufficient dose should lay the failure to the drug, when it is properly due to its faulty administration.

The thorough use of traction—*i.e.*, to the point of distraction—requires on the part of the surgeon not only a familiarity with the mechanical details of apparatus and the proper application, adaptation, and fitting of appliances suitable in each case, but the ability to arrange for such cooperation and assistance on the part of nurses or attendants as shall insure the continuance of the necessary amount of traction at all times. If this

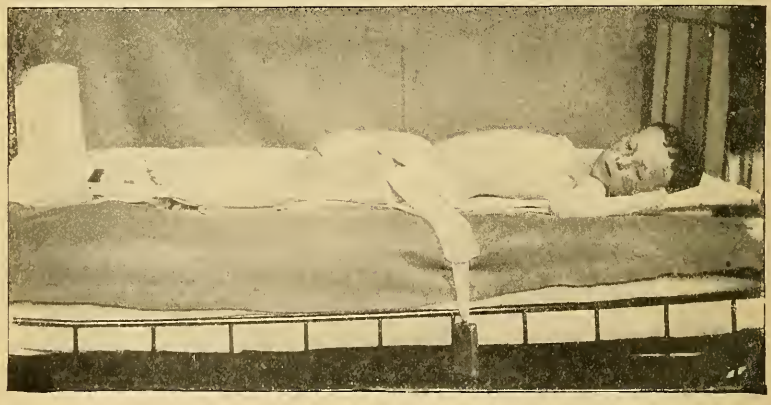

FIG. 228.—Lateral Traction in Hip Disease (C. G. Page.)

is not done the results are not complete, just as the lack of asepsis in an assistant or nurse may vitiate results in an operation, no matter how careful the surgeon may be personally. In the same way if, through the

neglect of a nurse, a hip which needs continued traction of from ten to fifteen pounds for protection against blows from muscular spasm is left during an acute stage for a time with a traction of two pounds, the joint may be seriously damaged.

Unusual care is required both in the management of cases and in the direction of hospital services. This care, however, is not greater than is possible if sufficient attention is given to the subject and the surgical indication borne in mind.

Fig. 229.—Plaster-of-Paris Spica Bandage. (Fiske Prize Fund Essay.)

It is therefore claimed that at a certain stage in hip disease traction force is desirable; that the amount of traction should be in proportion to the amount of muscular spasm, and continued as long as the spasm persists. It is also clear and demonstrable that an efficient traction force distracts, and it is manifest that distraction, or the separation of one inflamed bone from an adjacent inflamed bony surface, is desirable; that in this way every chance is given to promote cure and cicatrization of the previously inflamed bone. If an indication for surgical treatment is ever clearly written in pathological specimens, certainly that of distraction should never be overlooked. It should always be remembered that in treating hip disease at a certain stage the object should not be simply rest, or fixation, or protection from jar, but actual distraction, and that traction short of this is not sufficiently efficient.

The following mistakes in the application of traction are not uncommon: 1. The use of a weight too small to antagonize to any extent the muscular spasm at the hip. 2. The neglect of a counter-extending force, or the use of an imperfect one. 3. Imperfect hold upon the leg and thigh so that the traction will fall upon the knee and not upon the hip-joint. 4. Improper fixation of the patient's trunk and limb, allowing motion.

5. The use of the pulling force in such a direction that the force is not exerted in the line of deformity. The amount of weight to be used varies according to the case; the patient's sensation may be trusted in a measure. In cases of severe spasm, as much as twenty pounds will be found to be well borne, while in light cases and in small children four or five pounds may be sufficient.

The most ready way of applying prevention of movement of the patient combined with traction is by securing the patient to a gas-pipe frame and exerting, by means of a weight and pulley, the requisite pull upon the limb. Instead of the weight and pulley a traction attachment

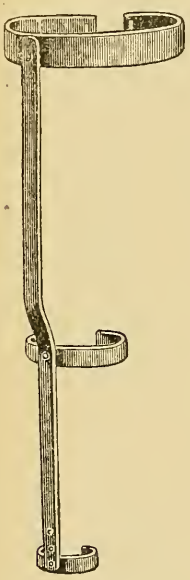

FIG. 230.

FIG. 231.

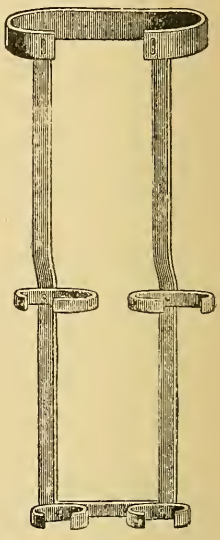

FIG. 232.

FIG. 230.—Thomas' Hip Splint, Single. (Ridlon.)

FIG. 231.—Diagrammatic Outline. Parallelism of body and leg portions. (Ridlon.)

FIG. 232.—Thomas' Hip Splint, Double. (Ridlon.)

to the frame can be employed with perineal counter-traction, or a traction appliance worn in connection with the recumbent frame. In this the patient can be carried about without interference with treatment.

Lateral traction suggested by Phelps and investigated by Page[1] will be found of service in the acute stage, when employed in connection with fixation and longitudinal traction (Fig. 228).

Fixation.—When there are no indications for the employment of trac-

[1] Orth. Trans., vii., 239.

tion, yet it is desirable to prevent extensive movement at the hip-joint, the trunk and hip can be secured by a plaster-of-Paris bandage (Fig. 229).

The amount of fixation furnished by a plaster-of-Paris bandage can be made as great as possible by applying the bandage to the well limb as well as to the affected one, and continuing it well upward on to the thorax; but motion in the lumbar region is possible even under these circumstances, and no direct check is given to the increased intra-articular pressure from muscular spasm. Furthermore, the method is a clumsy and uncleanly one. It will, however, be sometimes found of use in unruly children or when the nursing is imperfect and the joint is sensitive.

FIG. 233.—Thomas' Splint Applied. Posterior View. (Ridlon.)

What has been said of the plaster-of-Paris spica, even when so applied as to hold the thorax and the other leg, is true of metal and leather splints, which do not so completely hold the joint as that does. These lack fixative power by virtue of the little hold which they have upon the pelvis, and although in many cases of hip disease they serve a therapeutic purpose in acting as an incomplete means of fixation, they cannot be advocated for general use.

The Thomas Splint.—The Thomas hip splint, invented by H. O. Thomas, of Liverpool, is an appliance much in use in England. It is a very simple apparatus, easily made, and having many points of usefulness. It consists of an iron bar extending from the inferior angle of the scapula to a little above the ankle; the upper end of which is attached to a chest piece which is at right angles to the upright and encircles the chest, fastening in front. There are two circlets of iron which grasp the thigh and calf. The appliance is kept in place by a wide chest band and a bandage around the limb, and can be bent to fit any degree of flexion existing in the diseased leg and applied to it in that position. The apparatus requires much skill in adjustment, as it is hard to fit and keep in place. The posterior bands should be made of hoop iron and should

be so placed on the upright that two-thirds of each band should be to the well side of the upright and one-third to the diseased side. The upright should be made of iron three-quarters of an inch wide by three-sixteenths of an inch thick. The chest band should be one and one-quarter inches wide and the other band three-quarters of an inch. Before the splint is applied, in addition to the band for the buttock, a twist should be made in the upright's longitudinal axis between the thigh and body bands, so that the thigh and leg part of the splint shall lie somewhat nearer the median line of the body than the body part. In Thomas' hands it was undoubtedly an efficient instrument, but an extended and careful use of the splint by the writers, in many cases under all sorts of conditions, has led them to a preference for methods of treatment by traction. A Thomas splint cannot be said to furnish complete fixation, nor does it prevent the occurrence of subluxation, or counteract the spasmodic muscular contraction of the muscles connecting the lower extremity with the pelvis, so important a feature in hip disease. There are two points in the use of the splint upon which Thomas laid much stress. The patient must not go about while muscular spasm and joint irritability are present. And the limb must not be disturbed even for purposes of examination unless absolutely necessary and then only at intervals of weeks or months. The appliance, however, prevents motion of any great amount, enables the patient to be lifted without jarring the hip, and prevents and corrects flexion of the thigh. In certain acute cases the pain may be increased by the Thomas splint, from the fact of the imperfect fixation furnished. For inasmuch as the leg and thigh are firmly held by the flat rod to which they are bandaged, and this rod extends up the trunk, the trunk cannot be so firmly fixed to it that some motion will not be possible at its upper end, as the patient turns in bed or moves.

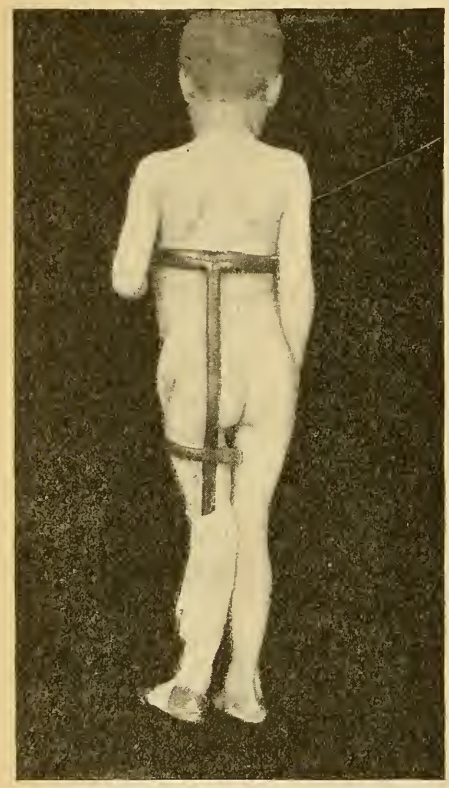

FIG. 234.—Thomas' Splint Outgrown and Neglected. Consequent bad result. (Fiske Prize Fund Essay.

Motion of the upper end of the rod is, of course, communicated to the lower, and the joint may in this way be twisted and jarred by the long lever attached to the thigh.

A double Thomas splint is more efficient as a means of fixation, but it does not easily permit locomotion. In a single Thomas splint a raised patten is put under the shoe of the well foot and crutches are used. This appliance certainly furnishes a ready and fairly efficient means of treatment of hip disease in the acute and subacute stage.

A substitute for the Thomas splint, made of stout iron wire, introduced by Dr. A. T. Cabot, of Boston, will be found of use in the case of smaller children. This is practically a posterior wire splint to the trunk and affected limb. Made of stout "copper-washed" iron wire it can be easily bent to fit any case, and is covered with canton flannel after the wire has been wound with sheet wadding. A body swathe holds the

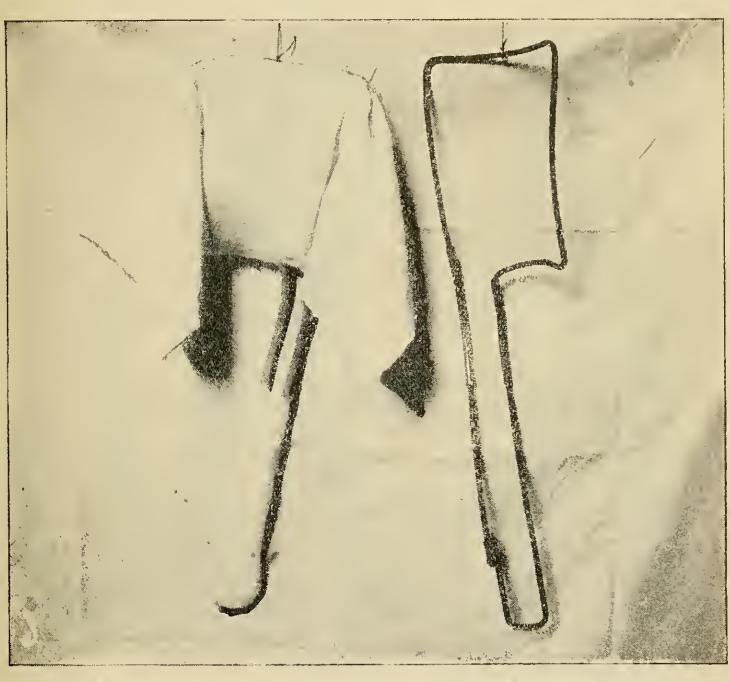

FIG. 235.—Cabot's Posterior Wire Splint. (Fiske Prize Fund Essay.)

upper part of the splint in place and the leg is bandaged to it. For young children with flexion of the leg it is an admirable splint, but it fails to fix the limb perfectly.

Wire Cuirass.—The gouttière de Bonnet, or wire cuirass, furnishes excellent fixation.[1] It is, however, cumbersome and expensive, and has

[1] For a modified and improved wire cuirass, see Nicaise: Rev. de Chir., January 10th, 1888.

the defect of not thoroughly giving the benefit which can be afforded by traction in relieving the increased intra-articular pressure, unless furnished with arrangements for traction and counter-traction.

Phelps, of New York, has shown a method of fixation by means of a readily made fixation appliance.[1]

Immobilization and Ankylosis.—Much has been written in reference to the danger of ankylosis incurred by the immobilization of diseased joints.

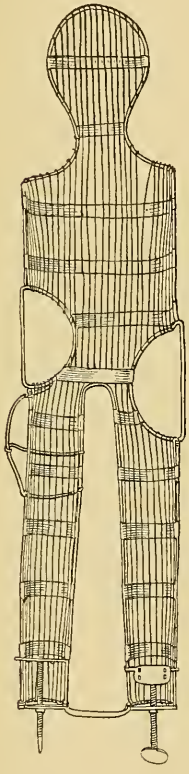

FIG. 236.—Gouttière de Bonnet. (Fiske Prize Fund Essay.)

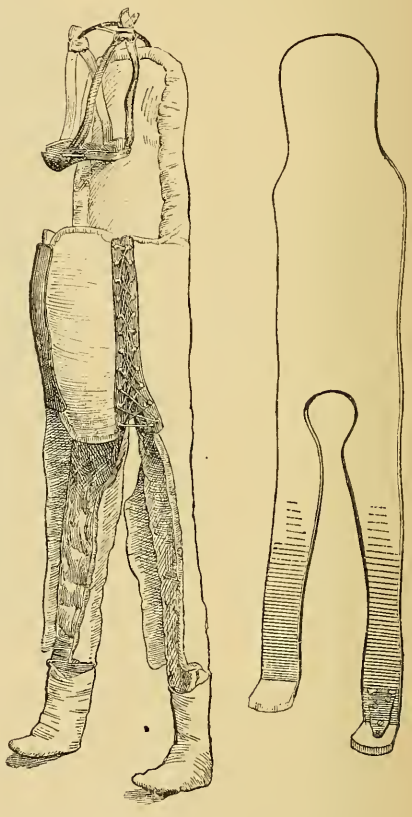

FIG. 237.—Phelps' Fixation Appliance.

That fixation of a healthy joint even for prolonged periods does not cause ankylosis has been demonstrated by Phelps[2] and Reyher. The most common cause of ankylosis in diseased joints is of course in the cicatrization of the inflamed tissues. Any measure which tends to limit

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[1] N. Y. Med. Rec., March 4th, 1889. [2] N. Y. Med. Jour., May 17th, 1890.

inflammation tends naturally to limit rather than increase the ultimate impairment of motion. The cardinal objections to fixation as a mode of treatment are that it cannot be made complete and that it does not antagonize the harmful effects of the tonic muscular contractions.

Traction.—Reflex spasm of the muscles about a joint is constant in all inflamed joints surrounded by muscles, and it is of especial importance

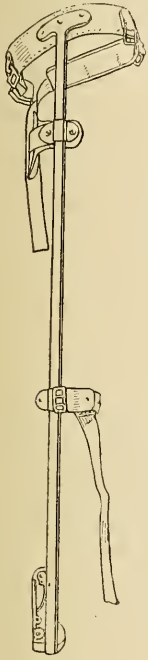

FIG. 238.

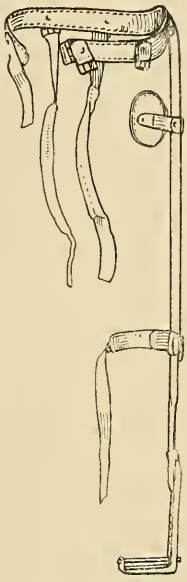

FIG. 239.

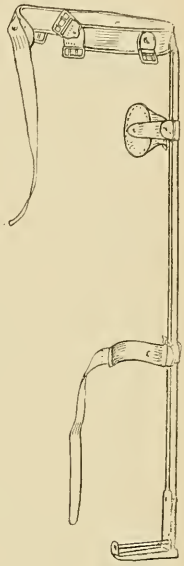

FIG. 240.

FIGS. 238–240.—Forms of the Long Traction Appliance. (Fiske Prize Fund Essay.)

in hip disease, from the strength of the muscles about the joint. The harmful effect of such spasm has been already discussed.

Traction Splints.—Traction splints exert their power upon the joint by virtue of pulling down the leg against a counter-point of pressure furnished by the perineum. A number of appliances have been devised for the purpose of traction, the principle of which is practically the same, viz., perineal resistance with a pulling force exerted on the limb.

The traction splint in common use is some modification of the original Davis splint. This form of appliance is now generally known as the "long traction splint," as well as the "Taylor splint" and the "Sayre long splint"; and various modifications of it are identified with the

names of the surgeons who have devised the alterations. A traction appliance consists of an outside steel upright reaching from the trochanter

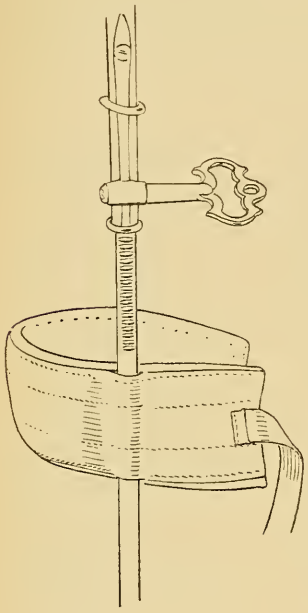

FIG. 241.—Windlass and Ratchet for Extension (Fiske Prize Fund Essay.)

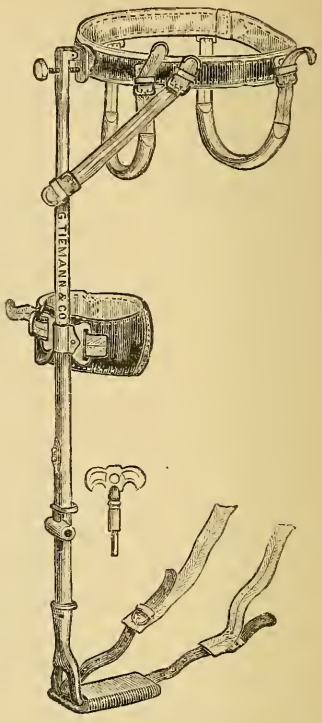

FIG. 242.—Traction Splint.

to below the foot; at the upper end is a horizontal rigid pelvic girdle in which the patient is secured by one or two perineal straps; to the bottom of the shaft is attached some appliance for exercising traction upon the limb, the latter being held to the bottom of the splint by means of adhesive plaster gaiters, circular straps, or bandages.

The adjustment of traction is easily provided for in several ways. One is by means of a sliding rod moving within a tube, the extension of the splint being controlled by means of a key and ratchet, a catch securing the rod when in the proper position. Two perineal bands are better than one; a splint with one band only, has the disadvantage in acute cases of affording less complete fixation to the diseased joint than the form with the pelvic band and two perineal straps.

The lower end is furnished with a broadened piece, bent so as to pass under the foot, and straps are attached to it which can be buckled into buckles secured to the adhesive plaster on the patient's leg.

A cheaper arrangement for traction can be furnished by means of a small windlass on the foot piece of the splint, turned by a key with a ratchet. Upon this windlass are two pins, or a rod with two slits in it, to which the traction straps are attached. By turning the key traction to any degree may be exerted.

The upper end of the splint terminates in a horizontal flat band encircling about three-fourths of the pelvic circumference just below the level of the anterior superior spines; it should reach from the anterior superior spine of the well side around the diseased side to a point in the back nearly behind the end of the anterior arm. The back arm should be slightly longer than the front one. Buckles or studs for perineal bands should be placed on this horizontal band. The sole piece should extend two inches below the sole of the bare foot. There should be a posterior semicircular band for the thigh and one for the calf.

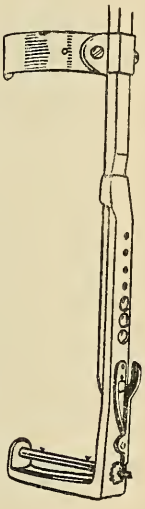

FIG. 243.

FIG. 244.

FIG. 243.—Windlass and Ratchet Appliance for Extension. (Fiske Prize Fund Essay.)

FIG. 244.—Long Traction Appliance. (Children's Hospital Report.)

Perineal bands may be made of webbing covered with canton flannel or chamois skin or silk; pads made of ground cork and covered tightly with chamois are useful. Leather sewed smoothly around a leather strap is the cleanest perineal band of all; but in the hands of careless persons it becomes hard with the constant wetting from urine, and is liable to chafe.

A very useful perineal band was devised by Brackett. It is especially comfortable in adult cases and in the larger children, and offers a distinct advantage in this way over any perineal band that the writers have ever used. The posterior bar is connected by a strap (*E*) at its centre to the posterior arm of the brace, thus allowing either end a certain amount of vertical oscillation. The three buckles are fastened to a similar bar (*F*),

which has two straps to connect it with the anterior arm, little or no motion being allowed. Between these straps and the perineum is a piece of leather (*G*), its size regulating that of the pad, which is fastened to the bar behind. This serves to transmit the pressure of the straps, and also to keep them in position, which is accomplished by buttonhole slits, through which the straps pass. The position of the straps is as follows: The outer one (*A*) passes along the outer border, and is secured to the outer buckle (*H*).

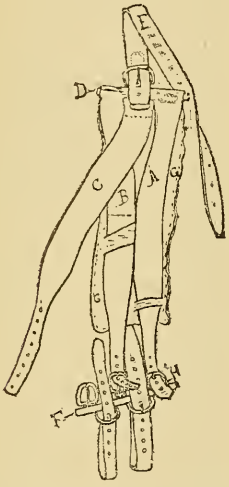

FIG. 245.—Brackett's Perineal Band.

FIG. 246.—Long Traction Splint. (From the Fiske Prize Fund Essay.)

It should pass beneath the tuberosity of the ischium. The second, or middle one posteriorly (*B*), crosses obliquely inward to the inner buckle, and by this more nearly corresponds to the direction of the ramus to which it gives its support. The third, or inner (*C*), crosses the one just described, and is secured to the middle buckle, and gives its special support in the space formed by the divergence of the first and second. By this crossing, the inner edge of the pad is made concave, giving better adaptation to the parts. By this arrangement with buckles, the surface can be made to fit closely all the parts serving for support. Felting one-eighth of an inch in thickness may be used to cover the leather. More than this should not be used, as it interferes with the principle of the pad.

The care of the perineum is one of the important practical points in the treatment of hip disease when a traction splint is used. The kind of

perineal band chosen will depend largely upon the surgeon's personal preference, and often the choice has to be made by experimenting with different kinds. The perineum should be kept powdered, and it should be bathed in alcohol daily. When an excoriation appears the perineal band should be covered with linen which is well spread with vaseline or zinc ointment and changed often. If the chafed spot becomes worse, the perineal band on that side should be removed and the other band entrusted with the whole weight, or the child should be put to bed, the splint removed, traction by means of a weight and pulley in bed being used for a short time until the perineum is healed. Ordinarily, with proper care and cleanliness, the perineum is able to bear all the pressure needed.

Traction splints were intended for use in patients who are not confined to bed, but it will be found that traction splints can be made to render efficient service to patients even when it is desirable to postpone ambulatory treatment and confine

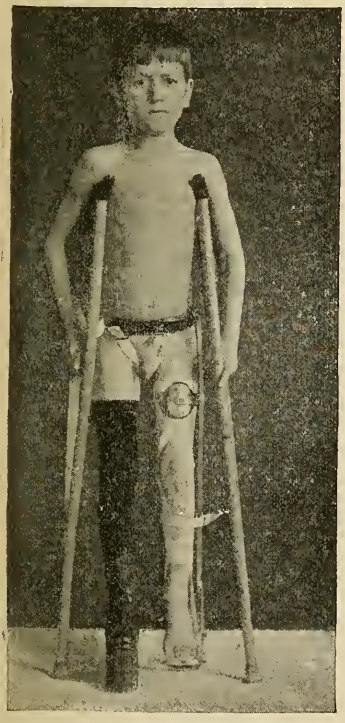

FIG. 247.—Long Traction Splint, with Crutches. (Children's Hospital Report.)

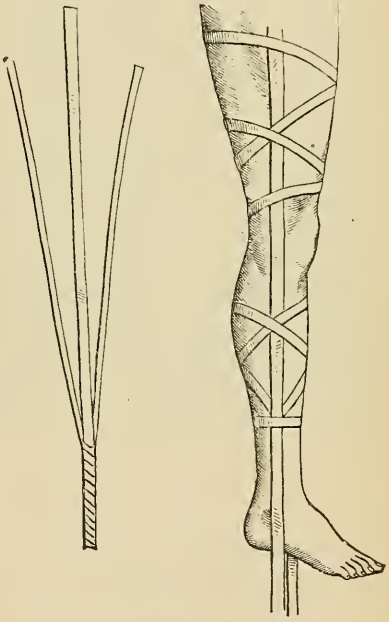

FIG. 248.—Adhesive Plaster for Traction.

the patient to bed. The traction furnished by traction splints will be found more thorough than that furnished by the weight and pulley methods.

Traction Straps.—The methods for securing a hold upon the limb, traction straps, as they are termed, are the same which are needed for

the traction by weight and pulley. The readiest way to obtain the hold upon the limb for an extending force is by means of adhesive plaster applied as indicated in the diagram. It should be applied firmly to the thigh above the knee. If applied to the leg alone, traction falls upon the knee, and may cause relaxation of the ligaments of that joint. Efficient plaster should be used, of a kind that will adhere readily without being heated. The plasters should be changed every three or four weeks, or

FIG. 249.—Plaster Traction Applied.

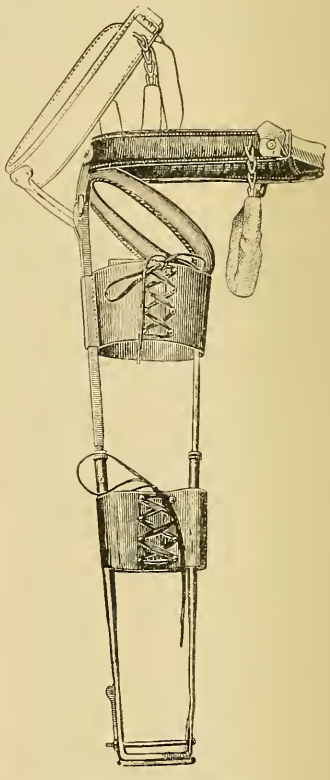

FIG. 250.—Modified Hip-splint. (Dane.)

oftener if they cause irritation. They can readily be removed, if the skin and plasters be thoroughly moistened with benzin or ether. If any portion of the limb is chafed by the plaster, it may be protected by means of a cloth covered with ointment placed over the part, and the plaster be applied over the cloth and the whole limb; or if the chafing is extensive, the whole limb can be covered with zinc ointment and protected by a smooth bandage, and the plaster put on over the bandaged limb. This will require frequent renewal, but will answer temporarily. A bandage applied over the plaster impedes the circulation, and increases the danger of eczema or chafing. If a bandage is applied over the plaster, and worn

for a few hours after it is first put on, sufficient adhesion of the plaster will be secured if proper plaster is used. In certain cases an obstinate eczema is occasioned by the adhesive plaster, and it is necessary to have recourse to some other means of extension. Substitutes for plaster are to be found, gaiters applied to the ankle, or straps above the knee. These, however, will slip if more than a slight traction force be applied and are not as a rule satisfactory. Another form of traction strap can be made in the following way: cloth is cut to fit the thigh and leg accurately; webbing straps and buckles or lacings are attached which when tightened give a hold upon the thigh above the knee. If straps are sewn to this leather or cloth legging, they can be made to furnish fairly efficient traction; but they are likely to slip, and are inferior to the simple adhesive plaster as a means of traction.

A means of traction can be furnished by what is called a stocking extension. This is made by applying to the limb a long tight-fitting stocking, which should reach above the knee, having tapes sewed at both sides, which should be longer than the child's limb, and reach a considerable distance beyond the upper part of the stocking; a bandage should then be applied to the leg over the stocking, and the tapes reflected down the leg outside the bandage, and a second bandage applied over the tapes, which should be long enough to extend down beyond the foot. If the tapes are fastened to the traction bar a pull upon the leg can be made.

A short traction splint has been somewhat used, exerting its traction by plaster extension upon the thigh with counter-traction by means of a perineal strap. It was originally thought that this appliance would be sufficient to meet the indications in the lighter cases, the patient being allowed motion at the hip-joint, walking by means of crutches; but it has proved unsatisfactory and therefore cannot be recommended.

Traction and recumbency in the most acute cases are necessary for a time; this can be furnished by means of a bed frame to which is added traction by means of a traction splint.

Various modifications of the long traction splint have been made, which aim, as a rule, at furnishing better fixation to the diseased hip than is given by the original long traction appliance. To furnish more unyielding counter-traction than is furnished by a strap Phelps and Dane have employed a padded ring similar to that in the ordinary Thomas knee splint. A combination of this with a thoracic band has been used, but when a frame is used this is unnecessary, and when this is not used the thoracic band (which cannot, while respiration is allowed, absolutely fix the thorax) furnishes an arm of leverage for a communication of the movements of the child's trunk to the sensitive hip-joint, especially if the limb is firmly attached by traction to the splint.

Recumbent treatment protects the joint from jar more thoroughly than if locomotion is allowed, but health-giving activity is to be permitted as

soon as the cicatrizing ostitis has replaced the destructive process to a sufficient extent to allow without detriment slight motion and jar inevitable even to a protected joint.

Treatment by recumbency is preferable to ambulatory treatment: 1. When sensitiveness of the hip is present as manifested by night cries or

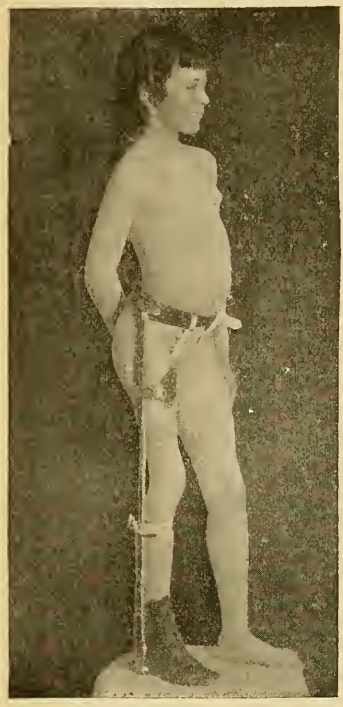

FIG. 251.—Convalescent Hip-splint. (Children's Hospital Report.)

FIG. 252.—Convalescent Splint. (Children's Hospital Report.)

sensitiveness on moving the limb. 2. When deformity is present to a marked degree during the acute stage. 3. When abscess is present or threatened. 4. In double hip disease until the stage of convalescence has been well established. 5. When the general condition of the child fails under ambulatory treatment. But the choice between treatment by recumbency and ambulatory measures is necessarily a matter of judgment varying in individual cases.

(*c*) *Protection.*—Certain methods of treatment aim at protecting the joint by preventing injurious jar from being inflicted upon the affected joint. The simplest way to protect a joint is with the use of crutches, the sound limb being raised by means of a patten on the shoe of the sound limb, enabling the affected limb to swing free of the floor. The weight of the limb exerts a certain amount of traction force, but this

method furnishes insufficient pull in children and does not protect the limb when the patient sits, or prevent careless patients from stepping upon the limb, and cannot be regarded as reliable.[1]

The ordinary "traction" splint, as described, is in reality a protecting as well as a traction splint, as it is longer than the limb and passes under the foot, enabling the weight to be borne upon the splint instead of on the patient's foot. Protection without traction can be furnished by omitting the sliding rod, and continuing the upright rod below the foot, and expanding it at the bottom as in the extension splint, or by inserting it into a socket in the boot. The upright of the splint should be long enough and the boot so arranged that the patient's heel should not touch the sole of the boot, though the ball of the foot may do so. The greatest jar in locomotion comes as the heel strikes the ground at the commencement of the step. If this jar is broken by the splint, the remaining jar to the hip in the step will be diminished at the ankle and knee, and the hip sufficiently protected, except during the acute stages of the disease.

FIG. 253. — Jointed Convalescent Splint with Curved Pelvic Band. (Ridlon.)

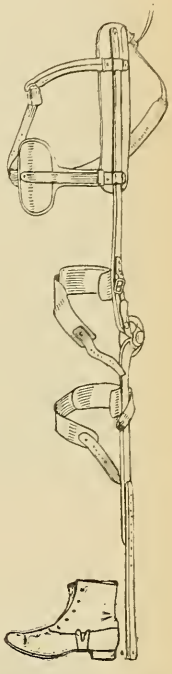

FIG. 254. — Convalescent Splint Jointed at Knee. (Fiske Prize Fund Essay.)

The ordinary protection splint should be like the long traction splint, an outside steel upright with a horizontal pelvic band at a level with the trochanter carrying perineal straps. It should be slotted below into a steel sole plate screwed to the bottom of the sole, and when the splint is in place and the perineal band buckled, the patient's heel should not touch the heel of the shoe, but hang an inch or so above it. A protection splint can be made hinged at the knee, and, if properly adjusted, patients can walk about readily with but slight discomfort. In this way reliable protection is secured during the long period of convalescence necessary for the thorough recovery of the affected epiphysis.[2]

[1] Hutchison: American Journal of the Medical Sciences, January, 1877.

[2] "Mechanical Treatment, Hip-Joint Disease," C. F. Taylor, New York; and E. G. Brackett: Boston Medical and Surgical Journal, October 6th, 1887.

If proper protection is neglected and not continued long enough, the jar of locomotion—the whole weight being thrown upon the epiphysis previously diseased—is sufficient to prolong the stage of irritability, to prevent complete cicatrization and ossification of the inflamed bone tissue, to promote contraction of the limb and distortion, and in many instances to give rise to relapses.

An appliance, which is not a great disfigurement, and will not interfere with locomotion, but will allow walking, and which can be worn without discomfort for years if necessary, is of great use in the treatment of convalescent hip disease. Simple protection without traction is not to be relied upon if muscular spasm is present. If muscular spasm is present, protection and traction should both be employed.

It is not necessary in young children that the splint be jointed at the knee in a protection splint. This is, however, of advantage in adults in a condition of what may be termed convalescence from hip disease. As the patient's condition improves, the splint can be shortened and jar gradually be allowed to come upon the limb. Protection is needed for some years after the subsidence of active symptoms. The need for the reapplication of protection is indicated by a reappearance of stiffness or increased limping on removal of the splint. The older the patient and the more active the process the longer protection will be needed.

Relapses.—Hip disease is not ended when the acute symptoms have subsided; a process which requires so long a time for its development

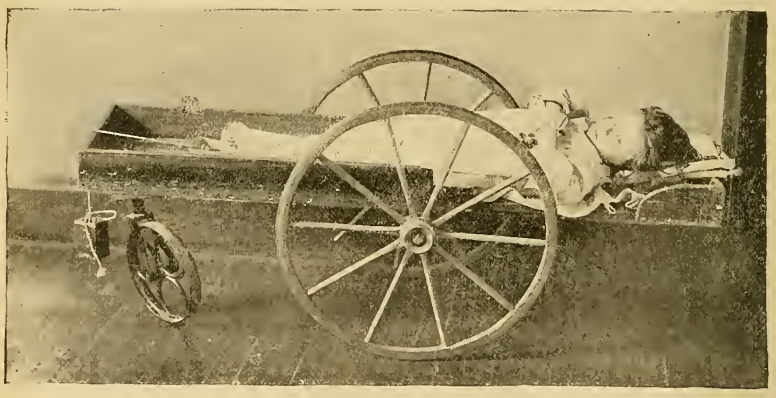

FIG. 255.—Ward Wagon for Acute Hip Disease. (Children's Hospital Report.)

requires also much time for its disappearance, it is safer not to discontinue traction and begin simply protective treatment as soon as the pain and acute symptoms are gone, and it is safer not to discontinue protective treatment until a long time has been given to the joint in which to recover itself.

When ambulatory treatment is attempted, it is desirable that both

crutches and apparatus be used, in order that every precaution against jar to the hip be taken. As it becomes clear that the danger of motion or jar at the hip has diminished, crutches can be laid aside, with the

FIG. 256.—Ward Chair for Acute Hip Disease. (Children's Hospital Report.)

continuance of traction as long as there is a tendency to contraction of the limb or muscular spasm. Later traction may be discontinued, but protection still maintained.

It is impossible to lay down rules as to the time of the continuance of treatment further than to say that traction and partial fixation should be continued until all acute symptoms have subsided and have been quiescent for months and only partial stiffness of the joint remains, due to inflammatory adhesions and not to muscular spasm, and that protective treatment should then be pursued for two or three years at least and discontinued gradually.

The Treatment of Complications.

Abscess.—Abscesses due to hip disease may in the early stages be absorbed in some cases under prolonged treatment by recumbency; such a method, however, seems hardly advisable as a rule, as such abscesses are easily accessible for operation and drainage.[1]

Abscesses may also be left to enlarge and break if for any reason this seems desirable in any individual case.

If abscesses are well localized and increasing in size, and burst spon-

[1] Centralblatt f. Chir., April 2d, 1881.

taneously, they often are thoroughly evacuated, leaving a sinus which, after discharging for some time, finally heals. Often, however, the abscess is not completely evacuated. Some residue remains, and, gravitating along the lines of fasciæ, it gives rise to the development of another abscess, until several collections of pus may be developed about the joint.

The experience of the writers in treatment by aspiration and the injection of germicidal solutions has not been favorable for the same reasons as those mentioned in speaking of Pott's disease.[1]

Free incision under strict antiseptic precautions is to be advised in all cases in which operation is not contraindicated on general surgical principles; exploration of the joint cavity should be made if the abscess communicates freely with it, and possibly softened bone may be scraped out. The abscess cavity should be examined for pockets, wiped out with dry gauze, and drained.

Sinuses, as a rule, persist for some time after operation. "Of forty-three cases of abscess of the hip operated on at the Children's Hospital, between 1884 and 1888, only one is recorded as having healed within six months, while about half of the sinuses healed within periods varying from one to two years, the rest remaining open."[2] In sixty-three cases operated at the Children's Hospital for hip abscess, one died ten days after operation of tuberculous meningitis. No sepsis occurred in any case. "As a rule the operation was followed by a decided improvement in the general condition of the patient, and by an improvement in the joint symptoms."[3]

A change in the mortality rate at the Alexandra Hospital in suppurative hip disease is attributed by Marsh to the fact that of late years abscesses have been opened and drained. Prior to 1880, the mortality in suppurating cases was 30.4 per cent, and 7 per cent in non-suppurating cases, while in a series of 614 cases reported by him more recently the mortality was only 6 per cent.

When efficient treatment is carried out, abscesses as a rule appear only in the severer cases, in which drainage is of benefit to the disease. The closure of abscess cavities by suture after the evacuation of their contents, while in rare instances it leads to permanent union by first intention, is not to be advised, as breaking down generally occurs. It must be remembered that the tuberculous infection is not confined to the wall of the abscess, but extends into the surrounding tissues.

Night Cries.—This troublesome complication usually disappears quickly after the establishment of thorough treatment. It is indicative of an active condition of the process of epiphyseal ostitis. In some

[1] N. Y. Med. Jour., March 2d, 1889.

[2] Boston Med. and Surg. Jour., September 18th, 1890.

[3] Orth. Trans., vol. ii., p. 87.

instances it persists for several weeks even under treatment. In such cases an abscess is usually developed, and with the incision of the abscess the sensitive condition disappears. The employment of phenacetin, salicylate of soda, chloral, has appeared to be of some efficiency in diminishing night cries.[1]

Although opiates, chloral, and bromide of potassium in large doses will often give relief, the use of them is to be avoided if possible.

Deformity.

The deformities occurring are flexion, abduction, and adduction. In the early stages of the disease when malposition occurs it is best corrected by putting the patient to bed and making traction in the line of the deformity.

Slight cases of deformity can be corrected by the use of appliances such as traction splints, which allow the patient to go about with the aid

FIG. 257.—Patient on Fixation Frame for Correction of Deformity. (Children's Hospital Report.)

of crutches; but in the severer cases rest in bed hastens correction. The traction splint naturally antagonizes adduction of the limb by virtue of its pulling the leg against a counter-point in the perineum which tends to abduct the leg to which the splint is applied.

If the patient is allowed to roll about in bed, or sit up, or hold the limb flexed at the knee, it is manifest that no proper traction force is being used.

The ill effect of a pulling force not in the line of the deformity in the acute stages of hip disease is evident. If an attempt is made to force the limb down, and a pull be made in the line of the axis of the body,

[1] R. W. Lovett: Boston Medical and Surgical Journal, April, 1889.

the head of the femur is crowded upward to the anterior edge of the acetabulum by the force applied at the end of the lever, viz., the femur, the contraction of the flexor muscles (holding the limb flexed) furnishing the fulcrum. In milder stages of the disease this is not so important as in the acuter stages, but it is a mechanical error in any stage to attempt traction except in the line of the deformity. This error is often the occasion of increasing the pain and sensitiveness in cases of hip disease.

When the deformity is of long standing and resistant, more force will be required.

Howard Marsh has employed an excellent method, which is easily applied in cases of adduction, using the ordinary weight-and-pulley traction on each limb, that applied to the adducted limb pulling downward toward the foot of the bed and that on the normal limb pulling upward toward the head of the bed.

In the correction of adduction a most efficient appliance is one recommended by H. L. Taylor.[1] It is used during recumbency and is particularly suited to the correction of the relapsed cases occurring in the late stages of the disease.

Brisement Forcé.—In more resistant deformity, forcible straightening under an anæsthetic will be of use, followed by fixation with a plaster-of-Paris bandage unless the resistance is so firm as to endanger fracture, in which case the method of subtrochanteric osteotomy is to be used.

Osteotomy.—Tenotomy, myotomy, and fasciotomy as a prelude to brisement forcé and osteoclasis have been superseded by the operation of subtrochanteric osteotomy. The operation in common use was devised by Gant;[2] in this the femur is divided below the trochanter minor. The anatomical reasons which he gave for this step were that the resistance of the psoas and iliacus muscles was set free and that a return of the flexion was not therefore to be expected, as when the bone was divided above the attachment of these muscles. He also called attention to the fact that in operating for ankylosis, after hip disease, it was desirable, if possible, to make the section through healthy bone and as far as possible from the original seat of the disease; in this way diminishing the liability of rekindling the old joint inflammation.

The osteotome is a chisel, which should possess a temper about halfway between that of a cold chisel and a carpenter's cutting tool, so that the edge of it will not be turned by the hardness of the bone. The cutting edge should be sharp and the width of the blade about half an inch. It is convenient to have several osteotomes of the same width, but of different thicknesses, so that if one becomes wedged in the bone it can be withdrawn and a thinner one substituted. The blade should be marked with a line every half or quarter of an inch from the cutting edges that

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[1] N. Y. Med. Jour., November 19th, 1887. [2] Lancet, December, 1872, p. 881.

one can tell how deeply the osteotome has penetrated. A fair-sized wooden carpenter's mallet answers better than any of the lead or steel ones found in the instrument shops.

In the performance of the operation the patient lies on the side with a sand pillow between the legs, and the skin is sterilized carefully. The chisel may be driven in through the sound skin about an inch or an inch and a half below the great trochanter, according to whether one is operating upon an adolescent or an adult. The chisel should at first be held with the blade in the long axis of the limb and turned when it reaches the bone, until its edge is at right angles to the axis of the limb. The osteotome should then be driven into the bone by sharp blows with the mallet, turning the cutting edge first forward and then backward, so as to cut obliquely through the whole shaft. If the osteotome becomes wedged it should be loosened by lateral motions and a thinner one substituted if possible. Any attempt at prying with the osteotome may result in breaking the blade and should be avoided. When the spongy tissue has been traversed by the blade of the chisel it will come in contact with the opposite wall of solid outside bone and will at once be felt to be driven with greater resistance. Then, as Macewen remarks, the osteotome acts as a probe as well as a cutting instrument. The bone should not be entirely divided, but when it seems evident that only a shell is left, attempt should be made to fracture the femur—very little force is needed, and if the bone does not yield easily the chisel should be again driven in still farther—always loosening it after each blow of the mallet, and directing the blade in a new direction.

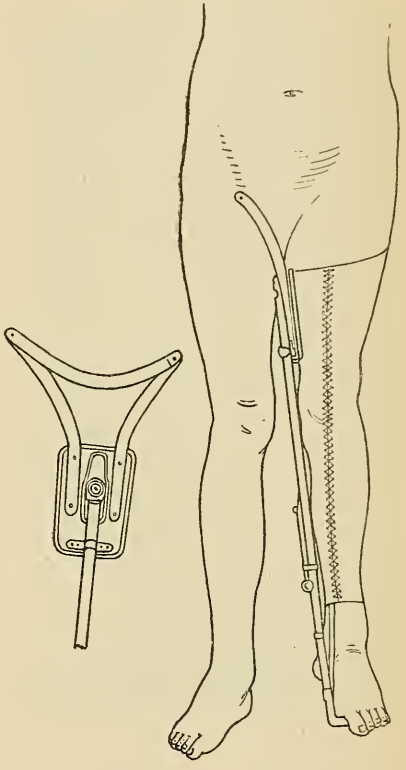

FIG. 258.—Taylor's Adduction Splint.

The bone breaks with a loud snap, and in most cases the flexed leg can be extended and the adducted one brought straight and no unnecessary manipulation of the bone should be made. Very little force is needed to correct the deformity, and if the leg does not yield to gentle

force then the best obtainable position should be taken and at some subsequent time rectification should be completed. There is little bleeding and scarcely any skin wound, unless it is necessary, as sometimes happens, to make a cut in the anterior surface of the upper thigh, to divide bands of contracted fascia which prevent full extension of the thigh. The patient should be placed on a bed frame and a light traction weight

FIG. 259.—Combined Pott's and Hip Disease with Ankylosis of Hip in Flexion (before Operation). (Goldthwait and Painter.)

FIG. 260.—Same Case after Subtrochanteric Osteotomy. (Goldthwait and Painter.)

applied or the limb may be fixed in the corrected position by a well padded plaster-of-Paris bandage including the whole trunk and limb.

Confinement to bed should last between five and six weeks. If adduction or abduction is present it should be corrected at the time of operation and the leg retained in the corrected position; and if it is desired to compensate for bone shortening it can be done by putting up the shortened leg in an abducted position. There is no need of a cuneiform osteotomy in these cases, as the simple linear cut makes rectification of the lateral deformity as easy as the correction of the flexion, but when marked deformity exists the osteotome may be driven obliquely through the bone. The risks attending the operation are very slight. Hemor-

rhage is very rare—although accidents have been reported from pressure on the femoral vessels by sharp edges of bone.[1] Marked improvement in the general condition of the patient often follows the operation.[2]

The ultimate functional results following the operation are excellent. Although there may be no motion at the hip-joint, the lumbar vertebræ are usually more movable than normal. The operation is indicated in all cases of severe deformity in which the distortion interferes seriously with locomotion.

Shortening of the Limb.—Simple shortening of the limbs after hip-joint disease and after excision occurs in a certain number of cases; nothing can be done to prevent this arrest of growth. Prevention of the development of the disease and such use of the limb as is compatible with safety of the joint (inducing proper circulation in the limb) may be regarded as the only means at our command.

Patients with much shortening of the diseased leg vary a great deal in the relief afforded by a high shoe; sometimes they find it of the greatest possible benefit, while at other times it is a constant annoyance. The shoe can be raised by a cork sole, or more cheaply by an iron or wooden patten, or by an ingenious arrangement in which the foot, like the stump of an amputated limb, fits into the socket of a specially constructed elongated boot, which conceals the shortening.

FIG. 261.—Marked Atrophy and Shortening. (Fiske Prize Fund Essay.)

DOUBLE HIP DISEASE.

In this distressing affection little difficulty is met in thorough fixation of the patient. By the ordinary frame and light traction in the early stages pain and deformity may be prevented. After the stage of spasm has passed the patient can be carried about in a double Thomas splint, and when convalescence is established locomotion with protection splints and crutches is possible. A traction splint on each leg is also a useful method of treatment. The chief difficulty in treating double hip disease

[1] Post: Ann. Anat. and Surg., January, 1883, and Rev. de Chir., December, 1881; C. T. Poore: "Osteotomy and Osteoclasis," New York, 1884.

[2] Goldthwait: Orth. Trans., vol. xi, p. 280.

is in the prevention of deformity, not during the active stage of the disease, but after convalescence has been established.

Deformity will probably not occur if patients are kept recumbent for a sufficiently long time to establish a perfect cure. If, however, they are allowed to walk or move too soon, before the joints are thoroughly strong, weight must necessarily fall upon the affected limbs in walking. If these are not sufficiently recovered to sustain the weight, deformity will ensue. This danger may be avoided by keeping the patient recumbent a sufficiently long time. Even with very little motion in either hip-joint locomotion is often possible, although the gait is necessarily restricted.

Excision of the Hip-Joint.

This method of treatment is based upon the opinion that, when a tuberculous affection exists, repair is hastened by the eradication of the diseased portion. Excision is less to be advocated at the hip than at the knee or ankle, for the reason that it is difficult and dangerous to remove the acetabulum, frequently primarily diseased in hip disease.

The removal of the acetabulum has been recently advocated by Bardenheuer, but the mortality of the procedure is sufficiently high to prevent its employment except for the more severe cases.

It is therefore impossible in a large number of these cases entirely to eradicate the tuberculous disease of the bone by excision, and ultimate cure must depend upon the overcoming of the tuberculous process by the process of repair. Excision in the early cases is therefore not justified when conservative treatment can be carried out for a sufficient time and with thoroughness. The removal of the head and neck, moreover, removes from the socket one of the supports on which the trunk rests, and the hip is more mutilated than after the cure by the natural process of gradual absorption, repair, and cicatrization, which leaves a firm though possibly ankylosed hip. After excision the hip is necessarily mutilated. The operation is therefore reserved for the severer cases.

Fig. 262.—Straight External Incision for Excision of the Joint.

Method of Operation.—Of the incisions in common use the straight external incision is the one most commonly used, and the most serviceable.

There are various varieties of the straight incision which are advocated by different surgeons. The incision as described by Sayre should begin at a point midway between the anterior superior iliac spine and the

great trochanter, the knife being pushed directly to the bone. The cut should curve to the top of the trochanter and then downward and forward, the length of the incision being from four to eight inches. Ollier's incision is less curved and begins four fingers' breadth below the crest of the ilium and the same distance behind the anterior superior spine of the ilium. It is then carried down to the top of the trochanter and follows down over the shaft of the femur.[1]

The tissues should be incised down to the bone, the soft parts should be divided, and the capsule opened. It is best to incise the periosteum of the trochanter, and if possible with a periosteum elevator to free it with its muscular attachments from the bone. Sometimes the whole trochanter can be uncovered in this way.

In using any of these incisions, after having made the cut down to the trochanter, and separated the periosteum on the outer side so far as practicable, the next step is to separate the soft tissues from the bone on the inner side, stripping back the periosteum as far as it exists as such. In advanced cases of hip disease, however, it will be found that all that it is practicable to do is to clear the periosteum from the outer aspect of the trochanter and then to separate the muscular attachments from the neck of the bone, keeping the knife as close to the bone as possible. Then passing the finger around the femur and adducting the leg slightly will raise the head of the femur out of the acetabulum, and the capsule can then be divided and the head of the femur thrown out into sight and sawed off, or the section can be made by a small saw or osteotome before dislocating the bone if the finger is kept inside of the neck of the femur as a guard. If the head of the bone is dislocated, it is more easy to see the limit of diseased bone and to make the section well in the healthy tissue. The objection to dislocating the head of the bone before section is that fracture of the diseased and atrophied shaft of the femur may occur if it is done roughly, and also periosteum may be stripped up from the inner aspect of the shaft and cause necrosis. When the head is adherent, it should be curetted or chiselled from its place.

The acetabulum should be examined and any sequestra removed and any carious surface should be scraped with a Volkmann's spoon. If the acetabulum is perforated, the edges should be chipped off until the point is reached where the periosteum lining the pelvis is attached to the bone. Bardenheuer has advocated removal of the acetabulum. In severe cases an incision along the iliac crest is made and the muscles are stripped down subperiosteally. The acetabulum is removed with a chisel or chain saw. In eight cases he removed the whole acetabulum and five recovered while three died. Sprengel has done a similar operation.[2]

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[1] Brit. Med. Jour., July 20th, 1889, p. 119.

[2] Deutsch. med. Woch., September 29th, 1898, p. 186.

It is impossible to remove all of the tuberculous material in excision of the hip; and this must necessarily lead to relapses and imperfect results in many cases. The mere removal of the head of the bone is a very incomplete measure for the eradication of the disease in those cases in which the tuberculous material has infiltrated all the tissues in the neighborhood of the joint. In many cases of extensive disease it is not easy to do a subperiosteal operation. In the severer cases the capsule is lax and partially destroyed, so that the finger when first introduced in the wound finds the head of the bone only loosely in contact with the acetabulum and dislocation is easily accomplished. The bleeding from the operation is generally trivial.

Before speaking of the after-treatment of the excision wound, it is necessary to speak of other incisions recommended for excision of the hip.

Anterior Incision.—A simple straight incision may be made from just below the anterior superior spine of the ilium and carried downward and slightly inward for three or four inches. The upper two-thirds of this cut should reach the femur, but the lower third should be more superficial. The capsule in this way will have been divided and the opening into it can be enlarged. Then with a narrow-bladed saw or osteotome the neck of the femur is divided and the head removed, but the Y-ligament should be left, as far as possible, intact. It is said that the anterior incision heals as well as any, and that there is no trouble about drainage, but drainage of course is not so free during the recumbency, which necessarily follows. Calot advocates a posterior counter-opening when this incision is used. Ollier exposes the trochanter, divides it transversely on a level with the head of the femur, carrying down the section to the head of the femur. The two halves of the head are then removed and the trochanter is replaced.

The experience of the writers leads them to favor the posterior incision.

After the operation a tube or a strip of gauze should be left in the most dependent angle of the wound and the rest may be sewed up if the tissues are not too much infiltrated with the products of inflammation. A heavy antiseptic dressing should then be applied and the child should be fixed on a bed frame, which may be widened at the hips to allow the change of the dressings without altering the child's position or disturbing the joint.

The hip should be fixed either upon a frame with light traction or in a plaster-of-Paris spica with the limb in an abducted position. As soon as it is practicable the child should be allowed to move about with crutches, wearing an appliance to prevent subsequent deformity, a traction splint, or a Thomas hip splint.

The mortality immediately after the operation is small (7 per cent),

provided extensive removal (*i.e.*, of the acetabulum) is not attempted; but the ultimate mortality some time after the operation is greater. In 2,464 cases tabulated by Wright (both before and after the introduction of antisepsis) the mortality was 34 per cent. The mortality of the operation cannot fairly be judged by generalizing from the results of operation before the introduction of antiseptic surgery. Leisrink's tables of operations done without antiseptic precautions set the death rate at 63.6 per cent. Culbertson tabulated 418 cases with 41.6 per cent mortality. Sayre's 75 cases gave 34.7 per cent. These were all without antisepsis.

Under modern methods the following groups of cases give the reported mortality:

	Cases.	Per cent.
Volkmann,[1]	48	25–30
Korff,[2]	33	48.5
Grosch,[3]	166	36.7
Alexander,	36	30.5
Children's Hospital, Boston,[4]	50	44.0
Hospital for Ruptured and Crippled, New York (Townsend[4]),	99	51.5

In the last two series of cases ultimate results were reported.

An analysis of 100 cases of excision of the hip by Mr. Wright, operated on since the introduction of antiseptic surgery, gives the following results, up to the time at which the patients were last seen: 17 soundly healed, 57 unhealed, 13 dead, 5 dying or going down-hill, 2 in a bad condition, 1 might need amputation, 4 had undergone amputation, 1 recent case doing well. As this table includes just 100 cases, the percentage results are apparent at a glance.

The causes of death after excision of the hip are, aside from the small per cent caused by the shock of the operation, due to the same causes as in hip disease not treated by excision, and it is certainly not true, as has been claimed, that excision of the hip is a preventive of systemic infection. That general tuberculosis and tuberculous meningitis supervene in a certain proportion of cases of hip disease is a fact well known. In the Alexandra Hospital, from 1867 to 1879, there were 23 deaths from tuberculous meningitis in 384 cases of hip disease. There were in these, 260 suppurating cases with 16 deaths (6.15 per cent), and 124 cases with 7 deaths (5.6 per cent). In these cases the treatment was conservative throughout. The risk, therefore, is a small one even in serious suppurative cases treated conservatively. Considering groups of cases treated by excision, Mr. Croft reported 45 cases with a mortality of 4.4 per cent from tuberculous meningitis. König, speaking from a very large experience in

[1] Verhdl. d. Deutsch. Ges. f. Chir., 1877, 59. [2] Deutsch. Zeit. f. Chir., xxii., 149.
[3] Cent. f. Chir., 1882, p. 228. [4] Orth. Trans., vol. x.

excisions, stated that the hope of immunity from tuberculous infection had not been gained by resection, even by antiseptic resection. Of 21 hip excisions, 47.6 per cent had died of tuberculosis in four years. Caumont found no preventive effect in his cases of resection. Of 26 cases treated conservatively, one-fifth died of tuberculous disease; while of 12 cases resected, one-third died of tuberculous infection. Mr. Barker, an advocate of excision, in his lecture at the Royal College of Surgeons in 1888 on the treatment of tuberculous joint disease, said that in no less than 10 per cent of all deaths following excision "rapid miliary tuberculosis supervened in such a way as to suggest strongly, if not to prove, that the surgical interference was the cause of the generalization of the disease."

FIG. 263.—Late Excision of Hip. Motion practically perfect. (Same case as Fig. 264.)

The statistics of Wartmann, based upon 837 resections, show that at least 10 per cent of all the deaths are caused by rapid general miliary tuberculosis, coming on in such a way that it is strongly suggested that the surgical interference stood in a causative relation. This point has been of late often alluded to, and the lesson to be drawn is that in excisions the work should be done cleanly, with as little tearing of tissue and opening of lymphatics as may be, with the most careful and constant irrigation. It may be stated then, in brief, that resection of the hip-joint as an operation is attended by an immediate fatality of about 7 per cent. The mortality of the disease after the operation cannot be estimated as less than 20 to 30 per cent, and when cases are followed up for several years it is higher still.

Functional Results.—After excision of the hip-joint the mechanical conditions are not favorable to the formation of a firm joint. After operation the head of the femur is gone and part or all of the neck. The capsular ligament is destroyed, and the upper end of the femur lies loosely against the ilium—perhaps at the acetabulum, perhaps somewhere else, and out of this very uncertain contact a new joint must be

formed if there is to be one, or else a union without motion. A new joint is established in successful cases, as has been shown by Küster, Sayre, Israel, Woodward, and others.

In these cases a synovial sac may develop, and the head of the bone is bound firmly to the ilium so that a comparatively useful hip-joint remains. Such a case is figured in the frontispiece of Sayre's "Orthopedic Surgery" (second edition), in which there has been the formation of new

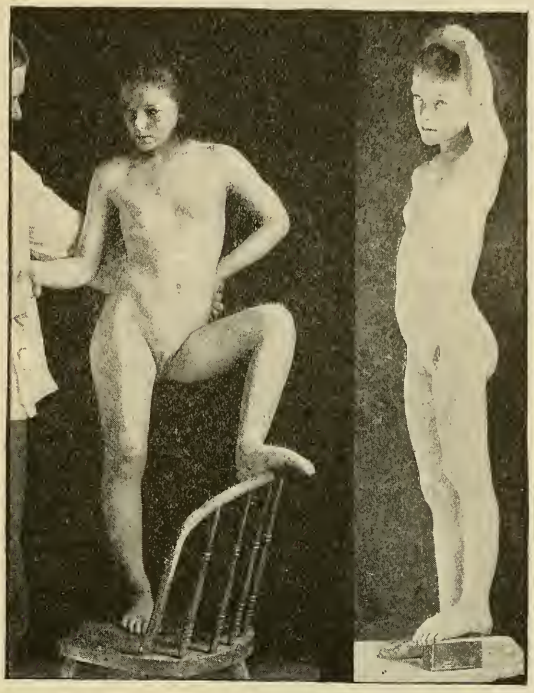

FIG. 264.—Late Excision of Hip. Motion practically perfect.

cartilage and new fibrous tissue, but the usefulness of the limb after successful excision is less than after recovery under non-operative treatment. In some instances a limb which was in excellent condition immediately after the operation becomes ultimately entirely useless. An illustration of this was reported by one of the writers' in a patient seen five years after excision. In Culbertson's tables[2] the case is reported as follows: "(No. 464.)—Recovered in six and two-thirds months; one-half inch shortening, almost perfect motion. Last heard from six and two-thirds months." Though the limb at the time of the patient's reported condition of cure was in a favorable condition, five years later the boy could only touch the floor with the toes of his affected limb, and was

[1] N. Y. Med. Jour., April, 1879. [2] Transactions Am. Med. Assn., 1876, p. 142.

unable to walk without crutch or cane and could bear little or no weight on the affected limb.

It is difficult to determine definitely how large a proportion of useful limbs ultimately result in cases in which recovery has taken place after excision of the hip. Elben[1] traced out 61 cases and found that 41 could walk without any apparatus, 15 could walk only by the aid of apparatus, and 5 could not walk at all. The Clinical Society's committee investigated very carefully 12 cases which were cured. Two could stand and hop on the excised limb, 4 could stand firmly, 4 were able to stand but not firmly, 2 could not stand.

FIG. 265.—Late Excision of Hip. Result fair. Walks with apparatus, but limps. (Fisk Prize Fund Essay.)

Sherman[2] reported 64 cases of excision with 13 deaths. Of 6 the condition was not known (22.4 per cent). Of 32 cases reported in a table the following was the condition of the cases seen at least four years after operation:

Age at Time of Operation.	Time since Operation. Years.	Shortening. Inches.	Extension. Degrees.	Flexion.	Abduction.	Progression.	Limp.
4	8	$2\frac{3}{4}$	180	130	30	Nearly equal.	Bad.
7	7	2	160	90	0	One crutch.	
4	6	$1\frac{7}{8}$	180	90	30	Nearly equal.	None.
8	5	$1\frac{1}{8}$	180	100	10	Equal.	Medium.
3*	5	..	....	....	....	.....	Slight.
16	5	..	145	90	....	Crutches.	
6	$4\frac{1}{2}$	1	180	120	45	Equal.	Slight.

* Reported by neighbors to be able to walk and run like other boys.

[1] Cent. f. Chir., 1879, No. 2; Med. Times and Gaz., November 3d, 1877.

[2] Orth. Trans., vol. vi., p. 124.

In a similar series from the Hospital for the Ruptured and Crippled the following tables are of interest in cases not less than four years after operation:

Case.	Age at Time of Operation. Years.	Time from Operation to Examination. Years.	Shortening. Inches.	Extension. Degrees.	Flexion. Degrees.	Abduction. Degrees.	Progression.	Limp.	Atrophy of Thigh. Inches.	Atrophy of Calf. Inches.
1	4	8	2¾	180	130	30	Nearly equal.	Bad.	2½	1
2	7	7	2	160	90	0	Uses one crutch.	.....	..	..
3	4	6	1⅝	180	90	30	Nearly equal.	None.	⅛	¼
4	8	5	1⅝	180	100	10	Equal.	Medium.	3¾	2¾
5	3	5	..	....	....	....	.....	Slight.	..	..
6*	16	5	..	145	90	....	Uses crutches.	.....	2¾	2¼
7	6	4½	1	180	120	45	Equal.	Slight.	1½	1½

* Neighbors report him to be in splendid health, able to walk and run like other boys.

TABLE SHOWING SHORTENING, MOTION, NUMBER OF SINUSES PRESENT, AND ANGLE OF GREATEST EXTENSION IN 12 CASES OF EXCISION. (FROM TOWNSEND'S SERIES.[1])

Number.	Date of Operation.	Time since Operation. Years.	General Condition To-day.	Sinuses Present.	Angle of Greatest Extension.	Motion. Degrees.	Shortening. Inches.
1	June 13th, 1890	6¾	Good.	3	150	0	2½
2	December 5th, 1890	6¼	Fair.	1	135	0	4
3	February 10th, 1891	6	Good.	0	180	100	3
4	April 24th, 1891	5¾	Good.	0	180	35	3
5	June 2d, 1891	5¾	Fair.	0	145	10	4
6	September 8th, 1891	5½	Good.	1	165	0	1¼
7	April 18th, 1892	5	Good.	0	155	5	2½
8	July 1st, 1892	4¾	Good.	3	160	0	2½
9	October 7th, 1892	4½	Good.	0	160	0	2¾
10	December 9th, 1892	4¼	Good.	0	165	0	1¾
11	January 21st, 1893	4	Good.	0	150	0	1½
12	February 24th, 1893	4	Poor.	4	....	0	1½

SHORTENING AFTER EXCISION (TOWNSEND'S SERIES).

Shortening noted 6 years after operation, . . 4 inches in 1
" " 6 " " " . . 3 " " 1
" " 6 " " " . . 2½ " " 1

Average, ... 3.16 inches.

Shortening noted 5 years after operation, . . 4 inches in 1
" " 5 " " " . . 3 " " 1
" " 5 " " " . . 2½ " " 1
" " 5 " " " . . 1¼ " " 1

Average, ... 2.68 inches.

[1] W. R. Townsend: Orth. Trans., vol. x.

Shortening noted 4 years after operation,	. .	$2\frac{3}{4}$ inches in	1
" " 4 " " "	. .	$2\frac{1}{2}$ " "	1
" " 4 " " "	. .	$1\frac{1}{2}$ " "	2
" " 4 " " "	. .	$1\frac{1}{4}$ " "	1
Average, ...	. .	1.6 inches.	

Shortening noted 3 years after operation,	. .	$1\frac{1}{2}$ inches in	1
" " 3 " " "	. .	1 " "	1
" " 3 " " "	. .	$\frac{3}{4}$ " "	2
Average, ...	. .	1.08 inches.	

Sinuses exist after operation for 6 years in,	. . . . .	2
" " " " " 5 " "	. . . . .	1
" " " " " 4 " "	. . . . .	2
" " " " " 3 " "	. . . . .	1
" " " " " 2 " "	. . . . .	2
" " " " " 1 " "	. . . . .	12

In a series of 50 cases of excision of the hip done at the Children's Hospital from 1877 to 1895 it was possible[1] to report on the condition of 10, four years or more after operation. The interval ranged from four to fourteen years. One had his hip amputated later, a second was in poor general condition, but with the exception of the amputated case no one of the patients used a cane or crutch; one had 6 inches of shortening, one 5, one 4, one had 2 inches, and three had only 1 inch. The amount of motion in flexion in those of the 10 cases in which it was recorded was as follows: None, 25°, 40°, 45°, 60°, 65°, 80°.

The indications for excision can be stated as follows:

1. When conservatism is impossible owing to lack of facilities for thorough treatment, and the affection is rapidly progressive.

2. When a progressive destructive process has continued in the hip-joint unarrested by the most favorable conditions.

3. When the process is so acute that it threatens not only the destruction of the joints but endangers life.

4. When an extensive sequestrum is present.

European surgeons apparently resect a larger proportion of cases than would be the case under the indications just given.

Vincent, of Lyons, in 233 cases of hip disease treated at the Charité Hospital resected 52 (22.3 per cent).

Sasse believes that conservative measures can be followed in 75 to 80 per cent of all cases (leaving from 20 to 25 per cent of cases for excision), an estimate practically the same as Vincent's.

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[1] Lovett: Orth. Trans., vol. x.

Bruns,[1] reviewing forty years' work at the Tübingen clinic, found 600 cases which he reduced to 390 cases of authenticated hip disease; and of these, 69 were resected, making about 18 per cent, a proportion not far from those of the other Continental surgeons just mentioned. At the Children's Hospital, Boston, in 1,100 cases, 50 were resected, being at the rate of 4.5 per cent.

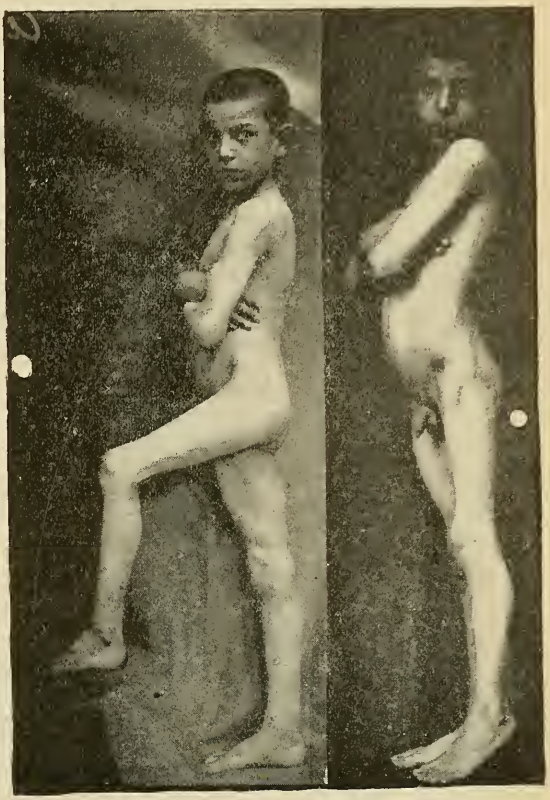

FIG. 266.—Late Excision of Hip. Motion in flexion 65°. Shortening one inch. Walks without crutches.

It must be borne in mind that results as to mortality after early excisions (before extensive destruction in the bone has taken place) are much more favorable than after late excision, as has been shown in the figures of Grosch. The results of careful conservative treatment, if carried out for a long time, are superior to those after excision in a majority of cases, and when conservative treatment is practicable it should be preferred. The functional results of conservative treatment so far as formulated in groups of cases treated by this method have been discussed under the heading of prognosis in this chapter. In large hospitals or among a poor and unintelligent class, conservative treatment is sometimes impracticable, and in such cases excision is resorted to earlier than would otherwise be justifiable, and the results gained are more satisfactory than when the operation is deferred. It must be evident, in comparing the mortality and the results of excision of the hip with the mor-

[1] Cent. f. Chir., 1894-96; Congrès de Chir., Proc. verbale, 481; "Coxalgie Tuberculeuse," Paris; Journ. de Méd. et de Chir., Annales, iv., 3, 261; Congrès Fr. de Chir., 1895, ix., 153; Jalaguier: Thèse d'Ag., Paris, 1868; Archiv f. klin. Chir., xxiv., 4, 719.

tality and the results of conservative treatment, that excision has no place in the routine treatment of the disease, because its mortality is higher and its functional results are inferior. The operation has, however, a decided

FIG. 267.—Late Excision. Poor result. No motion. Hip painful. Walks with splint. Three years since operation. (Children's Hospital Report.)

usefulness in late cases of hip disease, when it becomes distinctly a life-saying procedure, and in severe cases at an early stage when no home treatment or adequate hospital treatment for a long time is practicable.

Although the writers have been able to gain thoroughly satisfactory results after excision of the hip, and in a few instances have had reason

FIG. 268.—Late Excision of the Hip. Bad result. Cannot walk without crutch. (Fiske Prize Fund Essay.)

to regret not having resorted earlier to excision in cases in which conservative treatment proved unsatisfactory, yet after years of careful experience in the treatment of hip disease by both conservative and operative methods they would unhesitatingly record their opinion that the conserva-

tive method of treatment is preferable to the operative and that resection is needed only in exceptional cases.

Other operative procedures can be spoken of very briefly.

Trephining into the head of the bone was proposed by Fitzpatrick in 1867, who trephined for a short distance into the great trochanter and then attempted the destruction of the diseased focus in the head of the femur, by treating the bottom of the cavity thus made by inserting a stick of potassa cum calce. The same end may be reached by tunnelling through the trochanter into the head of the femur with a drill or gouge and evacuating any tuberculous material there. The operation is a serviceable one and often affords relief. It is especially indicated in acutely painful conditions of the joint, as it relieves tension and affords drainage.

FIG. 269.—Result of Hip Excision as a Life-saving Measure. One year after operation. (Fiske Prize Fund Essay.)

Incision of the Joint.—Incision into the hip-joint is of use sometimes in checking uncontrollable night cries, and in cases of exquisite sensitiveness of the joint in which tension of the capsule may be supposed to exist. A straight incision is made behind the trochanter major, and after the division of the muscles the finger can be thrust down to the joint, and on it as a director the capsule can be opened. The benefit from simple incision will not be found to be great in severer cases.[1]

Amputation.—The question of amputation of the diseased limb alone remains for consideration.

Neglected cases of hip-joint disease occasionally present themselves, in which, owing to extensive tuberculous disease of the pelvis or in the length of the femur, excision offers no chance for a cure; in other in-

[1] E. H. Bradford: Boston Med. and Surg. Jour., August 16th, 1888; Bost. Med. and Surg. Journal, April 26th, 1885, 392.

stances excision has failed to arrest the destructive process in the bone, and the surgeon is left to choose between surrendering the patient to a lingering and wretched death, and the very radical measure of amputation at the hip-joint. In making this choice he needs information as to the chances of recovery offered by amputation, and if the operation is decided on, as to the best method of procedure. The former cannot be found in the ordinary tables of mortality after amputation, as it would appear that the risk of death is greater when this operation is performed after injury, or for the removal of tumors, than when the patient is freed by the amputation from an extensively carious and useless limb, which has itself served as an impediment to recovery.

Ashhurst[1] collected 34 cases of primary amputation at the hip-joint for hip disease, and 31 after excision, and found 19 deaths. This, rejecting 5 cases in which the result was undetermined, would give a mortality of 32 per cent.[2] The death rate of amputation at the hip-joint after injury is 70.9 per cent, and for disease in general, 42.6 per cent.

List of Amputations at the Hip-Joint for Hip Disease, not Included in Ashhurst's Tables.

No.	Surgeon.	Result.	Reference.
1	Beddard.	Recovered.	British Medical Journal, June 7th, 1884, p. 1080.
2	Bradford.	"	Boston Med. and Surg. Journal, Dec. 11th, 1884, p. 564.
3	F. Jordan.	Died.	British Medical Journal, loc. cit.
4	"	"	" " " "
5	"	Recovered.	" " " "
6	Lediard.	"	" " " "
7	Littlewood.	"	" " " "
8	Lloyd.	"	" " " "
9	Lutz.	"	St. Louis Med. and Surg. Journ., 1879, xxxvii., p. 560.
10	Maclaren.	"	British Medical Journal, loc. cit.
11	"	"	" " " "
12	Marshall.	"	British Medical Journal, 1885, xliv., p. 220.
13	"	"	" " " " " "
14	"	"	" " " " " "
15	"	"	" " " " " "
16	"	"	" " " " " "
17	"	"	" " " " " "
18	May.	"	British Medical Journal, June 7th, 1884, p. 1080.
19	Pilcher.	"	" " " " " "
20	Roddick.	Died.	Philadelphia Medical News, 1885, xlvi., p. 220.
21	Shuter.	Recovered.	Clinical Society Transactions, 1882–83, xvi., p. 86.
22	Spofforth.	"	British Medical Journal, 1884, p. 1080.

According to Ashhurst, in 60 cases there were 19 deaths; in the table of later cases, 22 cases, with 3 deaths; making a total of 82 cases, with 22 deaths; giving a mortality of 27 per cent, and in the 22 more recent cases, not before 1880, a mortality of only 14 per cent. Still more

[1] "International Encyclopedia of Surgery," vol. iv., p. 501.

[2] One of these nineteen fatal cases (that of Buffos) should strictly be considered an operative success, as death did not take place till three months after the operation.

recently the statistics of Wyeth[1] and Levison[2] show a mortality for the operation by Wyeth's method of 11 in 85—15.29 per cent. In recent series in which other methods have been used the mortality remains considerably higher than this.[3] The mutilation which results is the chief objection to the operation, and is but partially met by an artificial limb. An undoubted reformation of bone has taken place in the case operated upon by one of the writers.

Absolute economy of blood—of the utmost importance in all hip amputations—is vital in cases reduced to the physical extremity seen in cases of hip disease undergoing this operation. The method of disarticulating, so popular in the operating classes, and known as Lisfranc's method, is not readily done if an elastic tourniquet is used. To check all bleeding, it will be found most convenient to amputate as if at the upper part of the thigh, and tie all bleeding points, removing the remaining fragment by a lateral incision. Or a lateral incision is made as in excision of the head of the femur, the head of the femur is excised in order that it may be out of the way, the lateral incision is prolonged and the shaft of the femur separated for two or three inches in its length from the surrounding muscles, taking care that the periosteum remain with the muscles. A circular amputation of the thigh is then done, the bone sawn through, or if entirely freed from the surrounding tissues by the lateral incision, pulled out from the flaps. The vessels are tied and the tourniquet is removed.

For controlling hemorrhage neither digital compression nor abdominal tourniquets are to be trusted, although the former can be used in children with less risk than in adults. A more serviceable way is that described by Jordan Lloyd.[4]

The limb should be elevated and stripped of blood, and an elastic bandage is doubled and passed between the thighs, its centre lying between the tuber ischii of the side to be operated upon and the anus. A pad in the shape of a roller bandage is tied over the external iliac artery, the ends of the rubber are drawn tightly upward and outward (one in front and one behind) to a point above the centre of the iliac crest of the same side. The front part of the band passes across the compress, the back part runs across the great sciatic notch and prevents bleeding from the branches of the internal iliac. The ends of the bandage are tightened, and should be held by the hand of an assistant placed just above the centre of the iliac crest.

The danger of hemorrhage may be still further diminished by transfixing the thigh from side to side above the line of incision and securing

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[1] Wyeth: Ann. of Surgery, xxv., 1897, 127.

[2] Levison: Jour. Am. Med. Assn., June 24th, 1899, p. 1428.

[3] Erdman: Ann. of Surgery, September, 1895. [4] Lancet, May 26th, 1883.

pressure with a steel skewer passing under the vessels. If rubber tubing be passed tightly around the ends of the skewer over the anterior surface of the thigh the front vessels can be compressed and the same method can be applied to the posterior vessels (Wyeth's method). The operation in this way can be performed without the loss of any appreciable amount of blood, and there is time for due deliberation, as there is no danger of a death upon the table by a sudden gush of hemorrhage.

The operation of amputation at the hip-joint has been performed three times at the Boston Children's Hospital in extensive disease of the hip and pelvis, with operative success in all, but with ultimate death from amyloid disease in two cases. Ultimate recovery took place in one who grew to manhood and at twenty wore an artificial limb fitted to a stump in which reformation of the bone took place from the periosteum.

The following conclusions would appear to be justified: amputation at the hip-joint, in hip disease, should be regarded as the very last resort, contraindicated by extensive amyloid degeneration of the viscera, or a moribund condition of the patient. The chances of mortality are not greater than those in amputation of the thigh in general, and the chances of a permanent cure (barring the mutilation) would appear to be greater than after excision at the hip-joint. The amputation should be done subperiosteally whenever it is possible. An elastic tourniquet with transfixion by long needles gives the best means of preventing hemorrhage. Preliminary excision of the head of the femur, in freeing the upper part of the shaft, will be found to facilitate the amputation.

Summary.—It is difficult to summarize the treatment of hip disease, for the reason that cases differ greatly in severity; some needing recumbency for a very long period, owing to a severe degree of sensitiveness or to the activity of the ostitis, while in other cases ambulatory treatment with proper appliances is sufficient without recumbency.

The proper treatment of hip disease is, therefore, not the exclusive use of any splint, but the use of such means as may meet the indications as they are present. During the acute stages, the hip-joint should be fixed efficiently in bed. This implies the use of thorough traction. Continued confinement to bed is not beneficial to the general condition of tuberculous patients, except temporarily during the acute stage; and as soon as the acute symptoms have subsided the patient should be allowed to go about with the hip thoroughly protected against jar and spasm. This can be done by means of a traction splint, if efficiently applied, with at first the additional protection from crutches.

If the acute symptoms return under this method, thorough rest in bed is again indicated in addition to efficient traction and fixation. If the acute symptoms diminish and there is less muscular rigidity at the hip-joint, greater freedom can again be allowed, and eventually traction discontinued, and the joint merely protected from jar. This should be con-

tinued so long as there is any danger of recurrence of active symptoms or tendency to contraction.

In brief, the hip should be fixed as long as it is sensitive, should be protected and distracted as long as there is muscular spasm, and protected as long as it is weak. The best results are attained only by thorough treatment for a year at least, and careful supervision and protection for two or three subsequent years. Distortions of the limb should always be corrected as they occur. In many cases some motion can be saved at the hip-joint if treatment is not discontinued too soon. Abscesses can be treated on general surgical principles. Radical operative measures are needed only in exceptional cases if thorough conservative treatment can be secured. Out-of-door air and the best obtainable surroundings are of great importance.

CHAPTER VI.

OTHER DISEASES OF THE HIP-JOINT.

Synovitis.—Arthritis deformans.—Charcot's disease.—Acute arthritis.—Malignant disease.—Bursitis.—Coxa vara.—Fracture of the neck of the femur in children.

Synovitis.

Acute, subacute, and chronic synovitis of the hip-joint occur at times.

Acute synovitis occurs as the result of trauma, and after dislocations of the joint; acute synovitis of the hip occurs at times in rheumatism (monarticular or polyarticular), in gonorrhœa, and under the same conditions existing in other joints in general.

The symptoms of acute synovitis of the hip-joint are not to be distinguished from those of acute hip disease in many instances. More or less complete muscular fixation, pain on motion, atrophy of the muscles, and even night cries may be present.

Chronic synovitis of the hip-joint results most often from a continuance of the acute form. A chronic sprain of the hip is often the accompaniment of the convalescence from impacted fracture of the neck of the femur. In the case of a young man under the observation of one of the writers, months after all bony repair had been ended, a chronic synovitis of the joint persisted, which was relieved by treatment protecting the joint. The extent of the synovitis and its course depend much upon the nature and amount of the injury and the condition of the patient. In patients with tuberculous predisposition, such injuries may produce tuberculous joint disease. In most cases, a synovitis passes away without permanent injury.

Diagnosis.—In the adult, chronic synovitis might be diagnosticated after a severe sprain of the joint in which the symptoms of an acute synovitis had clearly been present and had passed on to the chronic stage. When there is much distention of the capsule, swelling may be found in the groin below Poupart's ligament and behind the great trochanter. Flexion of the thigh is generally present, due to muscular fixation holding the thigh in that position. The affection is not common even in adults.

In children the diagnosis of synovitis of the hip-joint should be made only when recovery has occurred in a few weeks and has proved permanent.

Treatment.—The treatment can be summed up in a very few words.

In children cases of synovitis of the hip-joint are to be treated in the same way as cases of tuberculous ostitis.

Cases in adults, which are clearly to be recognized as synovitis, should be treated by rest to the joint, including, if necessary, either traction or protection by apparatus, and counter-irritation, blisters, etc., back of the trochanter. And every care should be taken to guard against using the unprotected limb too soon.

Arthritis Deformans.

Arthritis deformans of the hip-joint is an affection which is not uncommon in patients above the age of forty-five. It may occur as a monarticular affection or in connection with a simultaneous affection of some of the other joints.

Pathology and Etiology.—When affecting the hip it is known as senile coxitis, malum coxæ senile, chronic rheumatoid arthritis of the hip, etc. It begins in many cases insidiously, while in others, and especially monarticular cases, it follows after a fall upon the trochanter. From the shortening of the head and neck in these cases it was supposed by some writers to be an impacted fracture of the neck of the femur, but the shortening results from the absorption of the head and is in every way like the pathological changes found in the insidious cases.

There are apparently two classes of cases, basing the distinction on the pathological appearance of a large number of specimens. One class comprises those cases in which the hypertrophic changes predominate. These consist in an enlargement, thickening, and increase in density of the head of the femur. In the second class the atrophic changes predominate. The bone is lighter and is usually light and porous, or spongy, and the head and neck of the bone are diminished in size.

There are other cases which seem to hold an intermediate position, and in which both the hypertrophic and atrophic changes are combined.

Symptoms.—The affection begins with pain in and about the joint, often shooting down the course of the sciatic nerve at the back of the leg instead of down the front as in epiphyseal ostitis. At this stage the affection very closely simulates sciatic neuralgia. Movements of the joint beyond a certain arc are painful, and a noticeable limp is present. Flexion and eversion are particularly painful movements to the patient, and if the leg is manipulated a distinct creaking is sometimes felt which is most noticeable when the movements are most painful.

Muscular atrophy of the limb comes on and the nates of the affected side are flaccid and flattened, and apparent shortening from flexion and adduction is present in the diseased limb, as well as true bone shortening. Muscular fixation is at first not a prominent symptom, except in very sensitive conditions of the joint, but the arc of motion gradually dimin-

ishes until finally the joint becomes entirely stiff in perhaps a normal position, or perhaps adducted or flexed. In the earlier stages abduction and apparent lengthening of the limb may be present as in hip disease.

The position which the limb assumes in the more advanced cases of the disease is one which is calculated to be most misleading, especially when the affection has followed a fall upon the trochanter. The limb is rotated outward and, with the apparent shortening, presents almost a complete picture of an impacted fracture of the neck of the femur. In other instances the thigh may be flexed and adducted as in hip disease proper.

Arthritis deformans of the hip-joint does not go on to suppuration.

Diagnosis.—The affection is likely to be confused with sciatica and impacted fracture of the neck of the femur.

In sciatica the limitation of motion is governed by the amount of pain produced by the movement of the sensitive parts and by the tension on the nerve, and therefore differs from that resulting from true hip-joint disease. Flexion is usually free to a certain limit, but impossible beyond this and if the leg is held extended on the thigh this is particularly noticeable. In sciatica, hyperextension is not interfered with, nor rotation nor lateral motion. The diagnosis from true hip disease is based chiefly on the patient's age; tuberculous epiphyseal ostitis being quite rare in adults except in connection with well-marked tuberculous disease.

From impacted fracture of the neck of the femur the diagnosis may be almost impossible except for the history of the case and upon general surgical principles. There are no definite differential signs.

Treatment.—Morbus coxæ senilis or arthritis deformans demands treatment, first to relieve the pain, and secondly to correct the deformity.

The symptom of pain is rarely so great as to cause disability. In such cases hot baths, massage, galvanism, hot packs, and the administration of the remedies recommended in the treatment of chronic rheumatoid arthritis are often of use. The use of crutches and canes will often be needed. The deformities which follow this affection are usually those seen in hip disease, but they are more gradual in development. They are persistent and obstinate, but are amenable to proper mechanical treatment, such as is used in the deformities of hip disease.

H. L. Taylor[1] has related several cases in which rest to the joint was afforded by recumbency and traction and afterward the joint was protected for a long time by a simple protection apparatus like that advocated for use in convalescent hip disease. The results were favorable in the extreme. Joint irritation from overuse is to be met here as elsewhere by rest to the joint.

More is to be gained ordinarily by gradual correction by mechanical means than by forcible straightening in this class of affections of the hip.

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[1] "Senile Coxitis," N. Y. Med. Jour., December 15th, 1888.

Charcot's Disease of the Hip-Joint.

In frequency of attack the hip comes next to the knee, which among the large joints is the one most often affected. As in most other instances, Charcot's disease of the hip simulates very closely arthritis deformans of the ordinary type. The changes in the joint are, however, much more acute and extensive than those with which we are familiar in arthritis deformans. Synovial effusion is a more prominent symptom, sometimes reaching the stage of large fluctuating tumor which presents itself at the front and the back of the joint, with a wearing away of the head of the bone. The trochanter ascends and a state of affairs similar to the condition found in late hip disease is presented. In the matter of diagnosis, of course one depends upon the coexistence of symptoms of spinal-cord disease. As to treatment, nothing can be accomplished; in cases in which swelling is excessive, aspiration of the joint sac may give temporary relief. In cases in which syphilitic history is present, mercury or iodide of potassium should be given. Rest is indicated for the joint, with traction if it gives relief.

Acute Arthritis

may occur in the hip in early infancy. It does not differ from its usual course when situated in the hip except in its tendency to dislocate the hip or destroy the head of the femur. Such cases later in life may simulate closely congenital dislocation of the hip. When dislocation occurs, replacing the head of the femur and nailing it in place may be done, as in a successful case reported by A. Thorndike.

The other inflammations which may affect the hip deserve no separate mention from that already given them.

Malignant Disease of the Hip

is a rare affection.

The variety of tumor which most often affects the head of the femur in young children is a round-cell sarcoma of the periosteum. But the epiphysis is rarely the seat of the tumor. In seventy cases of sarcoma of the femur, analyzed by Gross, there were only two cases in which the upper epiphysis was affected.[1]

The early symptoms in cases in which the head of the femur is not primarily involved are very slight and consist chiefly of a swelling which is painless and not fluctuating; limp and slight restriction of motion may be present. Soon, however, it becomes evident that the enlargement is predominating over all the other symptoms and the swelling progressively increases, suggesting perhaps hip abscess. Fluctuation, however, is

[1] Am. Journ. Med. Sci., July and October, 1879.

absent and the swelling embraces the whole circumference of the limb. There is an enlargement of the superficial vessels and the swelling later becomes enormous. The patient becomes emaciated and wastes away. The affection may be very painful or again it may be attended with very little suffering. Amputation at the hip-joint, if performed sufficiently early, is the only remedy, but offers little hope of success.

FIG. 270.—Specimen of Coxa Vara. No clinical history.

LOOSE CARTILAGES

in the hip-joint are so exceptional as to be simply anatomical curiosities. The symptoms are similar to those described under the head of loose bodies in other joints. Their removal by operation is not easy.

BURSITIS.

Inflammation of the bursæ about the hip-joint must be recognized as a condition likely to give rise to symptoms possibly resembling hip disease.[1] This inflammation is most often traumatic, but may be tuberculous. Suppuration and the formation of fistulæ may occur. According to the location of the inflammation the symptoms will differ.

[1] Deutsch. Zeit. f. Chir., December, 1898; Brackett: Trans. Am. Orth. Assn., 1896.

The chief bursæ about the hip are as follows: The subiliac bursæ under the ilio-psoas tendon as it leaves the pelvis; the bursa under the insertion of the tendon of the ilio-psoas. About the trochanter major there are several: one between the fascia lata and the skin; a less constant one between the fascia lata and the trochanter; one under the gluteus medius; one under the tendon of the gluteus minimus; one between the obturator externus and the gemelli; one for the pyriformis; one for the obturator internus. A bursa further removed from the hip-joint, but one likely to be affected, is one between the gluteus maximus and the tuberosity of the ischium. This affection may be mistaken for hip disease, as there is limitation of motion and limp, and, in the severest cases, suppuration. The diagnosis at times can be established only after incision. The treatment consists of the temporary use of crutches and incision in the severer cases.

FIG. 271.—Photograph of Case of Coxa Vara. (Whitman.)

Coxa Vara

is the name applied to a deformity caused by the bending of the neck of the femur so that the normal relation between the head of the femur and the shaft is changed. The yielding generally results in the upward and backward movement of the trochanter and shaft. This is naturally represented clinically by an elevation of the trochanter above Nélaton's line, by eversion of the whole limb, by shortening of the limb, and by a limitation of abduction of the leg. The displacement may, however, be upward or even upward and forward.[1] In the latter case eversion rather than inversion is limited.

In 96 cases collected by Whitman there were 74 males and 22 females. In 23 the deformity was bilateral, and in 73 unilateral. In 2 cases there

[1] Whitman: N. Y. Med. Journ., January 21st, 1899.

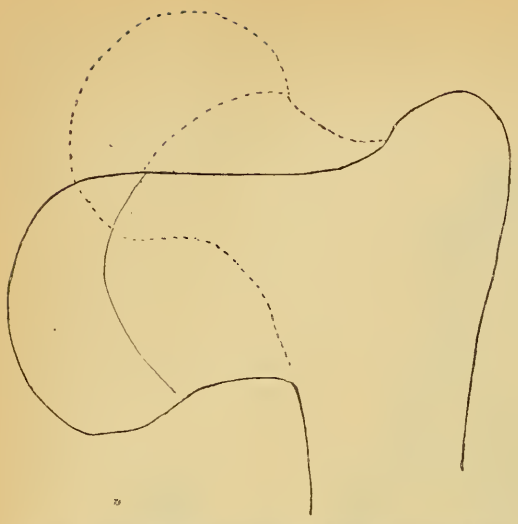

FIG. 272.—Outline of Depressed Neck of Femur in Müller's Specimen. Contrasted with normal (in dotted line). (Whitman.)

were 2 adults, 15 adolescents, 7 from 5 to 11 years, and 2 less than 5 years old.

It occurs most often in adolescence but also in childhood, and has been described as congenital,[1] in the latter case in connection with rickets.

In adolescents after a fall or strain, or often without cause, a stiffness and soreness in one or both hips may be noticed. At first it simulates an inflammatory affection. Later the diagnostic signs become evident. This is especially noted on flexing the thigh. These are shortening of the limb, elevation and prominence of the trochanter, outward rotation of the

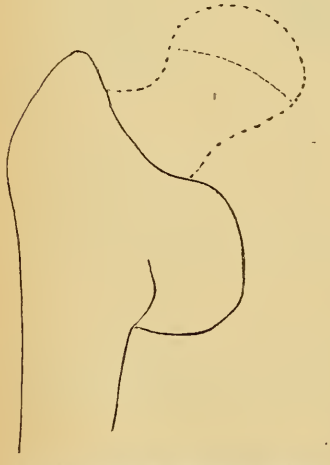

FIG. 273.—Outline of the Deformity in Hoffa's Specimen. Dotted line shows normal position. (Whitman.)

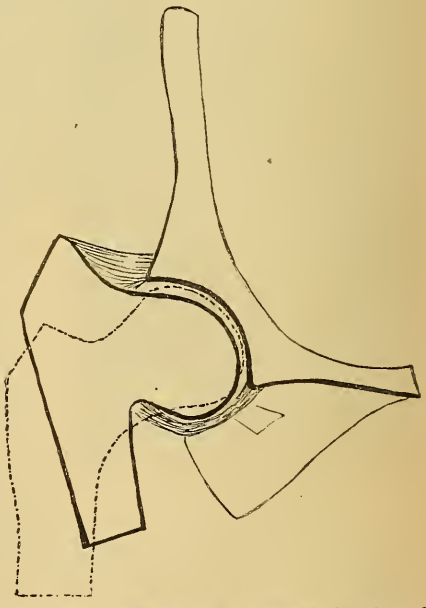

FIG. 274.—Cross Section of Pelvis and Deformed Femur. A scheme to show the effect of the deformity in limiting abduction. Dotted outline shows the normal relation. (Whitman.)

[1] Krebel: "Coxa vara congenita," Cent. f. Chir., October 17th, 1896.

leg, oftenest with eversion of the foot, and limitation of abduction due to the nearness of the trochanter to the ilium. When both sides are affected lordosis may be present and a swaying gait simulating spastic paralysis.

In bilateral cases the deformity may be so marked that cross-legged progression is necessary.

Among other symptoms to be mentioned are joint irritation, pain, and fatigue. The shortening sometimes in itself is a cause of discomfort and of limping. Scoliosis may occur secondarily as a result of the short leg.

The cause of the process which allows the bone to yield is by no means clear. In specimens of the deformity obtained by resection[1] there has

FIG. 275.—Same Case as Fig. 274, Showing Involuntary Crossing of the Legs in Flexion. (Whitman.)

been no evidence of disease in the joint or bone structure, except in Keetly's[2] case, in which a wedge of bone from the neck of the femur, removed to correct the deformity, is said to have shown "evidence of local rhachitis." In general, it appears that the evidence in favor of local rickets as a cause is not convincing when the signs of general rickets are absent.[3] In general rickets this deformity does occur, although it is not common to find it present to a marked degree.

Other causes which may produce the deformity are of course fracture of the neck of the femur, ostitis, osteomyelitis,[4] osteomalacia, and

[1] Roser: Schmidt's Jahrbuch, Leipsic, 1843, p. 257; Zeis, quoted by Whitman.
[2] Quoted from Whitman: Orth. Trans., vol. vii., p. 288.
[3] Münch. med. Woch., 1890, x., 93.
[4] Hoffa: Zeitsch. f. Orth. Chir., i., 55.

ostitis deformans, or ostitis fibrosa (Küster). There is no agreement as to the etiological factor in cases not falling into these obvious classes. Kocher has found microscopical evidence of juvenile osteomalacia. Kirmisson and Charpentier believe that in certain cases arthritis deformans exists. Certain cases examined have shown congestion and softening and slight irregularity of the epiphyseal cartilage, but apparently no more than might be found in bone bending as the result of overstrain.[1]

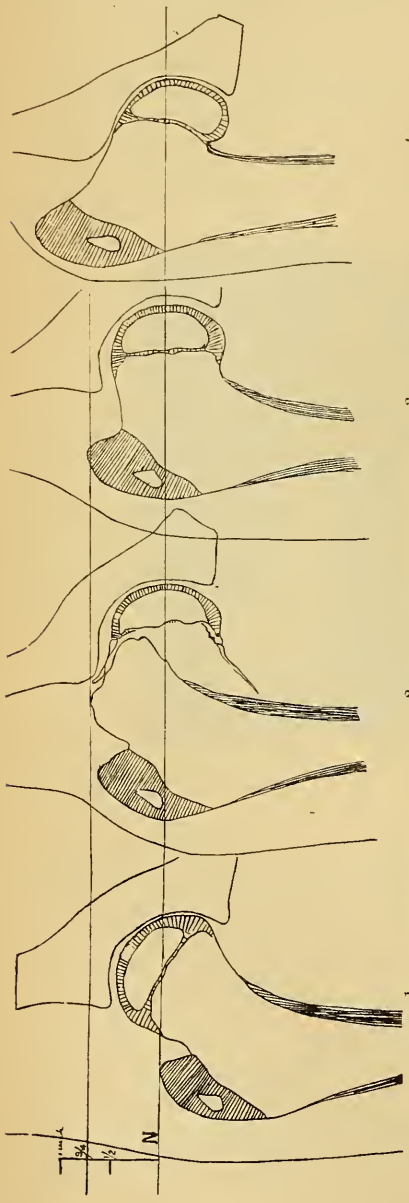

FIG. 276.—1, At Five Years; 2, Epiphyseal Separation; 3, Fracture with Depression of Head and Neck; 4, still further Depression of the Neck. (Whitman.)

Relative slenderness and weakness of the neck of the

FIG. 277.—Fracture of Hip Four Years after the Accident. Shows Eversion. (Whitman.)

[1] Whitman: N. Y. Med. Journ., January 21st, 1889.

femur, a normally varying angle between the neck and shaft of the femur, and the fact that a certain amount of descent of the neck of the femur is normal during adolescence, all suggest themselves as being pos-

FIG. 278.—Radiograph of Same Case as Fig. 277. (Whitman.)

sible factors in predisposing to the deformity. Injury, sudden strain, and constant overwork might act in such cases to produce a yielding of the neck of the femur.[1]

In certain cases, however, the yielding has been found rather in the

[1] Mikulicz: Arch. f. klin. Chir., xxiii., S. 561; Arndt: Wien. med. Presse, April 6th, 1890; Humphrey: Jour. Anat. and Phys., xxiii., 1889, p. 236; Humphrey: Loc. cit.; Lane: Trans. Path. Soc., London, 1886, 446; Wien. med. Presse, January 26th, 1868.

junction with the epiphysis of the head of the femur with the shaft than in any change in the angle of the neck.[1]

The affection is most likely to be mistaken for congenital dislocation of the hips, or hip disease.

In congenital dislocation the disability exists from birth, the hip-joints are unduly lax, and traction pulls down the femur in relation to the pelvis. Moreover, the dislocated head of the femur can be identified through the soft parts. The *x*-ray offers a means of diagnosis.

Fig. 279.—Fracture of Hip. Projection and elevation of trochanter. (Whitman.)

In hip disease the limitation of motion is generally in all directions; in coxa vara abduction is chiefly affected, and unless joint irritation is present, this limitation is not the result of muscular spasm. Coxa vara with irritation of the hip-joint is difficult to differentiate from hip-joint disease.

From fracture of the neck of the femur in its later stages the affection cannot always be accurately diagnosticated in obscure cases.

The prognosis without treatment is not good, as an increase of the deformity is likely.

The treatment consists in an osteotomy and correction of the deformity in the severer cases.

Osteotomy may be a wedge-shaped osteotomy of the neck of the femur (Kraske), or a linear osteotomy of the neck of the femur, or a linear subtrochanteric osteotomy with abduction of the limb to obviate the shortening of the limb.

Fracture of the Neck of the Femur in Children.

Malposition after fracture of the neck of the femur in children must be recognized as the cause of a deformity similar to that of coxa vara. Attention has been called to the subject by Whitman.[2] He believes, and is supported in this by his *x*-ray pictures and measurements, that frac-

[1] Kocher, Hofmeister, Nasse: Quoted by Hoffa, "Orth. Chir.," 1898, p. 606.

[2] Orth. Trans., vol. x., p. 221.

ture of the neck of the femur has occurred rather than epiphyseal separation. Symptoms of joint irritation are generally added to those of the injury alone as a result of the use of the leg, and if walking is kept up during the process of repair marked sinking of the neck of the femur may occur. In an adolescent patient under the care of one of the writers in whom an impacted fracture of the neck of the femur had occurred, one of the chief annoyances was the fact that the affected leg must always be flexed in an abducted plane. In sitting this caused much inconvenience.

The recognition of such fractures in children is of much importance and their recognition and treatment differ in no radical way from those in older persons.

The operative treatment is similar to that of coxa vara.[1]

[1] Hofmeister: Beiträge z. klin. Chir., xii., 1894, and xxi., ii.; Frazier: Annals of Surg., July, 1898; Alsberg: Zeit. f. Orth. Chir., vol. i., 1898.

CHAPTER VII.

TUMOR ALBUS OF THE KNEE-JOINT.

Definition.—Pathology.—Clinical history.—Diagnosis.—Differential diagnosis.—Prognosis.—Treatment, (*a*) conservative, (*b*) operative (excision,—arthrectomy,—amputation).

Definition.

The old term tumor albus is here applied to the most common of all knee-joint affections formerly known as fungous disease of the knee-joint.

Other names are tuberculosis of the knee-joint, scrofulous disease of the knee, chronic purulent or fungous synovitis of the knee, etc.

Anatomically, it should be noted that the joint surfaces forming the knee are nearly flat, and the facets in the tibia shallow. Owing to this fact, the tibia is easily drawn backward and flexed by the hamstring muscles, the flexors of the leg being much stronger than the extensors,[1] at the same time it is rotated outward, the combination constituting the common and troublesome deformity which is the characteristic one after severe tumor albus.

Pathology.

Tumor albus, as it is seen in children, begins oftenest, if not always, as an epiphyseal ostitis of the tuberculous type. Like other forms of tuberculous disease, it is oftenest limited to certain portions of the epiphysis, and either the femoral or tibial epiphysis may be attacked primarily. Cases are occasionally seen, however, in which the primary focus is in the patella or in the head of the fibula.[2] In children it is not uncommon to see an acute apparently traumatic effusion gradually absorbed, leaving an infiltrated and thickened synovial sac. In the greater number of cases, however, the bone symptoms clearly precede the effusion.

The pathological appearances of tuberculous joints have been so fully described in speaking of the pathology of chronic purulent synovitis and epiphyseal ostitis that it is not worth while to enter upon them here to any extent.

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[1] Lucke: Deutsch. Zeit. f. Chir., March 9th, 1885; Sonnenburg: Deutsch. Zeit. f. Chir., vii., p. 485; Fischer: Deutsch. Zeit. f. Chir., viii., 1–37.

[2] Nichols: Orth. Trans., vol. xi.

Owing to the large size of the articular ends of the bones which enter into the formation of this joint, it is not uncommon to find sequestra of considerable size in the bony ends, which are ordinarily in the form of a wedge with the base toward the joint. They are not, however, the accompaniment of early tumor albus.

In the severer cases a destructive, fungous, or purulent synovitis generally develops, which becomes the characteristic feature of the process. This may end in a complete destruction of the joint or in arrest and recovery by absorption and cicatrization.

FIG. 280.—Tumor Albus. Joint showed general tuberculous process, without visible connection with the primary focus, a cavity in head of tibia of three centimetres diameter, filled with cheesy material. *a*, Tuberculous focus in femur. (Nichols.)

CLINICAL HISTORY.

The affection begins, as a rule, insidiously, with stiffness and limp in gait. The disease may be limited for a long time, and be manifested by an enlargement of the condyles or head of the tibia, or it may extend and involve the whole joint; occasioning severe pain, swelling of the periarticular tissues, effusion into the joint, peri-articular abscess, and distortion of the limb, *i.e.*, flexion and subluxation, and ending in a natural cure with fibrous or bony ankylosis and a distorted limb, which may be more or less serviceable, according to the distortion; or the affection may result in such extensive suppuration as to endanger life from septic or amyloid changes. Sometimes in cases of moderate severity an attack of severe pains supervenes, and an acute stage is reached, when the limb is flexed at the knee, hot and tender to the touch, and sensitive to any jar. Under proper treatment this stage gradually subsides, and there may be left impairment of motion. Enlargement of the bone, if it persists for any length of time, is characteristic of chronic epiphysitis of the knee.

The swelling at the knee, unless suppurative synovitis is present to a marked degree, differs from that of synovitis with effusion, in that the swelling is of the bone and soft peri-articular tissues, and is not alto-

gether within the joint. If the effusion is large, as in chronic serous synovitis, the patella, when the muscles holding it are relaxed, can be depressed by pressing on it, and be felt to hit against the bone as it floats above the fluid within the joint. In effusion the shape of the swelling is characteristic. When effusion is the characteristic feature, it is most prominent on both sides of the patella, and is limited by the tendon of the quadriceps extensor muscle and by the ligamentum patellæ.

FIG. 281.—Tuberculous Knee in Adult. General synovial tuberculosis. Large irregular area of tuberculous softening in epiphyseal end of femur, extending into joint along crucial ligaments. *a*, Tuberculous focus. (Nichols.)

In tumor albus the chief symptoms are heat, swelling, tenderness, and joint distention; while in hip disease, the joint being less accessible, a different class of symptoms, restriction of motion, limp, and distortions of the limb, are more to be depended upon.

In tumor albus the knee will be seen to have lost its definite contour, the depressions on the sides of the patella have become filled out so that there is an indistinctness of outline which is as perceptible to the touch as to the sight. Most often the patella seems to be raised from its position by a semi-solid mass and the whole knee seems surrounded by a boggy infiltration. Later it assumes a spindle shape and the distention causes the skin to be somewhat anæmic in the more severe cases, whence the name of tumor albus.

In some instances, one of the condyles—usually the internal condyle—is enlarged more than the other, causing knock-knee.

In the milder cases, arrest of the disease may occur at any time with more or less complete restoration of the joint. In the severer cases suppuration may follow, with the establishment of sinuses. The destructive

FIG. 282. — Knee-joint; Excision for Deformity after Old Tumor Albus. Partial occlusion of artery by projecting spur of tibia. Gangrene. *a*, Wire marking line of popliteal artery; *b*, line of union of femur and tibia. (Nichols.)

FIG. 283. — Tuberculous Knee, Process of Repair Advanced. Small focus persists. *a*, Tibia; *b*, tuberculous softening; *c*, femur; *d*, patella. (Nichols.)

process may become so extensive that excision or amputation is required. In general, the affection is favorably affected by proper treatment.

Atrophy of the muscles, both of the thigh and calf, is present, and reaches a serious degree in acute cases. It is quite equally distributed between the muscles of the thigh and those of the leg.

Shortening is a much less important factor than in hip disease, and until late in the affection does not appear to any extent, and this late shortening comes as a result of the faster growth of the well leg oftener than as the outcome of bone destruction. During the course of the disease *lengthening* of the affected leg may occur. The hyperæmia occasioned by the inflammation induces the overgrowth in all directions of the tibial and femoral epiphyses, so that they outstrip for a while those

of the other leg. In measuring a child with tumor albus it is, therefore, not uncommon to find the diseased leg half an inch longer than the other. Later in the disease, the trophic disturbance which occurs in all these tuberculous joint affections makes itself felt and the diseased leg falls behind the well one in its growth.

FIG. 284.—Tumor Albus. Appearance of dry bones.

Pain.—The pain of the affection is, except during the acute exacerbations, not severe, though pain on jarring the limb is common. Night cries are much less common than in hip disease, but they occur. When, however, the patient does suffer from an acute exacerbation, the pain and tenderness are excessive. From the exposed condition of the joint jars and twists are very common, and the suffering may be extreme. Tenderness is very common, especially over the inner surface of the head of the tibia. In certain cases, however, the knee is held rigid by muscular spasm, and any reasonable manipulation fails to occasion any pain.

Heat of the affected joint is present and is a most valuable index of the progress of a case. It can be easily felt with the hand as long as the disease is active, but when it becomes quiescent it disappears, to return if anything goes wrong. It can be felt to diminish if treatment is successful in quieting the condition of the joint, and is a most urgent indication for protective treatment so long as it exists in any degree.

Lameness is a constant symptom. It varies with the sensitiveness of

the joint and is much influenced by the amount of flexion present in the diseased knee.

Muscular fixation is a symptom of this as of all chronic tuberculous ostitis, but is less prominent than in the hip. In the early stages it may be practically absent. The joint may be held perfectly rigid in full extension or in partial flexion, or a certain arc of motion may be permitted and then the muscles quickly catch the joint and prevent it from going

FIG. 285.—Tumor Albus. Acute severe case.

farther. Persistent muscular spasm results in the characteristic malpositions of the affection, flexion, and subluxation of the tibia, and muscular spasm is an early symptom, perhaps the earliest of all.

Malpositions of the limb result from the greater power the flexor muscles of the thigh possess in contrast to the extensors. The limb becomes gradually flexed almost from the first, and if the affection goes on without treatment, flexion may reach a right angle, and this is the tendency of the disease throughout and a marked obstacle to its successful treatment.

Even when the affection is nearly cured, the slightest imprudence on the part of the patient is likely to bring back the flexion, which is accompanied by increased heat and tenderness. Together with the flexion,

and as a result also of the predominance of the flexor muscles of the thigh, subluxation of the tibia backward occurs; this is due to the shape

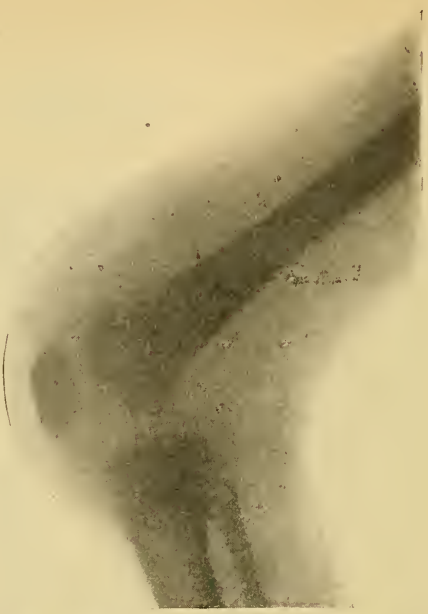

FIG. 286.—Radiograph of same Case as Fig. 285, Showing Indistinctness of Lower End of Femur, where Focus of Disease is Situated.

of the joint surfaces, and the persistent contraction of the hamstring muscles always pulling the tibia backward. If the leg has assumed this

FIG. 287.—Subluxation in Tumor Albus.

distortion and is straightened, the tibia will lie in a plane back of that of the femur, and the part of the knee formed by the femur and patella will be unduly prominent.

Another result of long-continued muscular spasm is the external rotation of the tibia upon the femur, which accompanies severe grades of flexion and persists after straightening of the leg if such is accomplished. In the same way a certain amount of knock-knee is apt to be present in the corrected limb after severe grades of tumor albus.

FIG. 288.—Position of Deformity in Tumor Albus.

Abscess appears either as a purulent distention of the capsule, which may point at any part of the surface and discharge by sinuses for an indefinite time, or abscesses form in the peri-articular tissues as in hip disease. As a rule abscess formation is accompanied by an acute degree of the affection.

DIAGNOSIS.

The diagnostic symptoms and signs in tumor albus are an intermittent lameness; a general enlargement of the knee-joint, with a feeling of stiffness and pain on using the limb; heat over the joint; and the

FIG. 289.—Flexion of Knee with External Rotation of the Tibia.

FIG. 290.—Severe Flexion of Knee-joint in Acute Tumor Albus.

presence of local tenderness and muscular stiffness in manipulation of the joint.

The character of the enlargement of the knee-joint is of great importance.

Differential Diagnosis.

Synovitis.—Gross errors in diagnosis in affections of the knee are not common, as a thorough examination of the joint is readily made. The distinction between a synovitis with effusion and a chronic ostitis is based on the size and shape of the swelling. A diagnosis between a subacute synovitis without effusion and an epiphyseal ostitis at an early stage is difficult or impossible.

Practically it is very often extremely hard to differentiate simple synovitis from a beginning tumor albus, indeed it is in many cases impossible to do. Sluggish cases of synovitis, especially in young or feeble persons, should be regarded with very great suspicion, inasmuch as they are likely to eventuate in tumor albus at any time, if the condition is not already that.

Peri-articular Disease.—Peri-articular disease (inflammation of bursæ, and peri-articular abscesses) is to be distinguished from true articular disease in that there is little or no joint stiffness, and that the swelling, if present, does not bear the relation to the patella that occurs when there is fluid beneath the patella; the distention being clearly outside of the joint sac.

Functional disease (hysterical, neuromimetic) of the knee is to be recognized by the absence of objective symptoms, and the prominence of subjective symptoms. Heat is generally absent, limitation of motion and tenderness may be excessive, and swelling and alteration of the joint contour are absent.

Arthritis deformans of the knee occurs as a spindle-shaped enlargement of the bones, with but little tenderness and a perceptible thickening of the synovial sac, with infiltration of the peri-articular tissues. Motion is more or less lost by structural changes, and in irritated joints muscular spasm is present. A very characteristic sign is a peculiar creaking which is felt with the hand on the joint while it is being moved. The existence of other signs of rheumatoid arthritis is important.

Rheumatism, both acute and chronic, may simulate tumor albus. In certain cases a diagnosis is impossible except by aspiration of the joint fluid and inoculation into a guinea-pig to demonstrate the presence or absence of tuberculosis.

Hæmophilia may cause an inflammation of the knee closely resembling tumor albus. The diagnosis must be made by establishing the existence of the bleeder's diathesis.

Prognosis.

The prognosis of tumor albus is similar to that of the same affections of the other large joints. The functional results after conservative treatment are in average cases excellent; sometimes perfect motion is restored, but in general only an incomplete arc remains with occasionally complete rigidity. The earlier that treatment is begun, and the more faithfully it is carried out, the better is the outlook as to functional result. In advanced cases disability necessarily follows, and in neglected cases deformity of the limb, flexion at the knee, subluxation of the tibia, and the formation and discharge of abscesses are likely to occur, ending either in a complete destruction of the joint or in a cure with ankylosis. A liability of the dissemination of the tuberculous disease to the brain or lungs exists in this as in other similar affections.

In all severe cases there is a danger of permanent distortion of the limb. This may be so severe as to render the limb useless. Flexion of the limb is a constant result in severe cases unless treated with great care. Shortening is less likely to exist to a troublesome extent than in hip disease.

As in all cases of epiphyseal ostitis of the larger joints, the prognosis as to the time of requisite treatment depends not only on the time needed to check the inflammation, but also for the re-establishment of sound bone tissue capable of bearing weight without danger of relapse. This in growing children demands a long time. Protection is generally necessary for from one to two years, and perhaps even longer, after the acute stage is ended.

Treatment.

The treatment may be classed as conservative and operative.

Conservative Treatment of Tumor Albus.—What was said in regard to the treatment of hip disease may be repeated in speaking of epiphysitis of the knee-joint. The treatment should be thorough and persistent, and should meet the indications, and fixation and protection are the most important indications in diseases of the knee, while traction is less so. The employment of protection should be continued until it is probable that the epiphysis is normal, which is a matter of judgment in every case. Protection should be discontinued gradually and tentatively; if discontinued too soon, recurrence will take place, or the deformity of the limb will increase. Fixation should be used so long as there is any activity of the inflammation; this is indicated by pain, muscular spasm, or tenderness. Efficient fixation of the knee does not requite confinement to bed except in very acute cases, in abscess, and in deformity.

Fixation.—It is manifest that the most thorough fixation is made if

the fixing appliance is as long and extends as high as possible. The leg and femur, if much longer than the appliance, will have a greater mechanical advantage than if the splints are sufficiently long. It should also be borne in mind that owing to the fact that the thigh is well covered by soft tissues a certain amount of motion is possible owing to the yielding of the soft parts. Fixation by stiff bandages is an efficient method of treatment when the bandages are properly applied. They should reach from the groin to the ankle, and as firmly as possible grasp the muscles

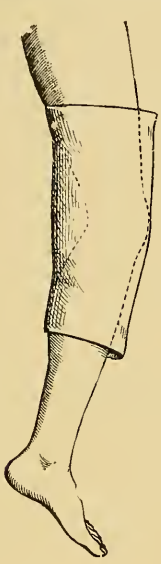

FIG. 291.

FIG. 292.

FIGS. 291 and 292.—Imperfect Fixation of the Knee by Plaster Bandage.

of the limb. Plaster-of-Paris is the most available material for use. The method does not give in all cases certain, definite support. Judson says in regard to it: "It may be an exaggeration, but it conveys the idea, to say that a plaster-of-Paris or silicate splint, applied to the leg and thigh, contains a mass of jelly in which the femur is but little restrained from motion," and in a degree this is true of all stiff bandages.

The figure shows the inefficiency of a loosely applied plaster bandage so far as fixation is concerned. Other stiff bandages are of silicate of potash, leather, celluloid, wood pulp, papier maché, etc. They may be cut down the front and laced so as to be removed at any time. Fixation without protection is inadequate treatment when locomotion is desired. For this reason it is insufficient to apply a stiff splint to the affected leg and to allow the patient to walk without further protection of the limb.

Fixation as a means of treatment so far has been considered only as applicable to the limb in its straight position. Much more often a degree of flexion is present to complicate matters, the treatment of which will be considered later.

Protection.—Protection can be furnished by means of crutches, and raising the sound limb by a thick sole which allows the affected limb to

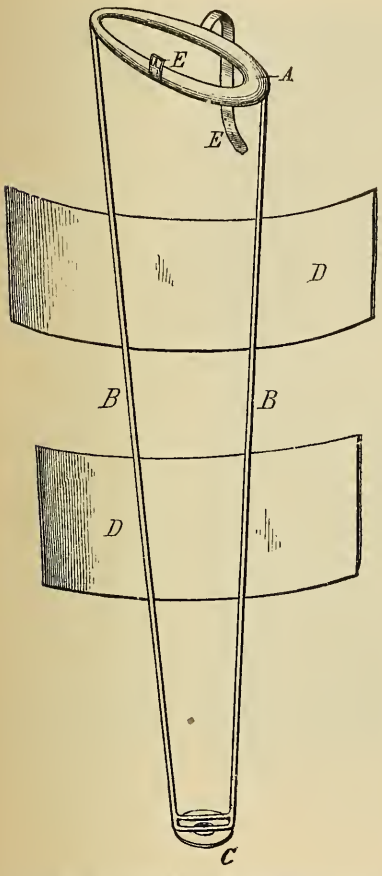

FIG. 293.—Thomas' Knee Splint for Right Leg. *A*, Perineal ring; *C*, foot piece; *D*, leather lacings; *E*, straps to go over shoulder.

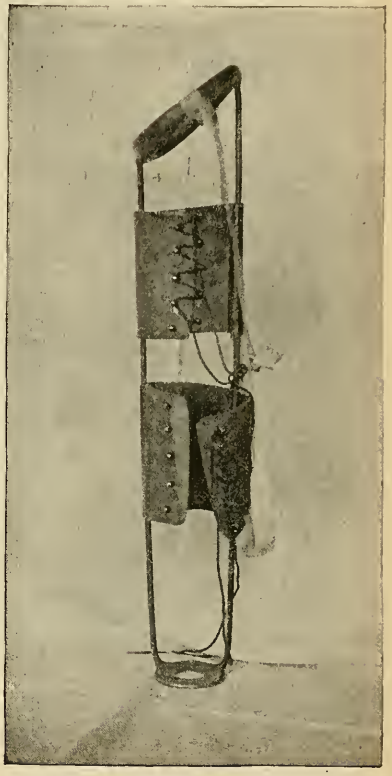

FIG. 294.—Thomas' Knee Splint. (Children's Hospital Report.)

swing clear of the ground. Better protection is furnished by means of a splint with perineal support and longer than the limb, which passes below the foot so as to take the jar of locomotion. The best of these splints is one similar to that already described as a protective splint in hip disease. It will be described more fully in speaking of the treatment of flexion in tumor albus.

A simple appliance is the Thomas knee splint, which consists of a

padded iron ring fitted so as to surround the thigh at the perineum, and fastened to two rods on each side of the limb, longer than the limb and secured at the bottom to a metal plate below the foot or bent to fit into a slot under the shank of the boot. The thigh ring is placed at an angle of 55° to the uprights, which angle is reduced by the padding of the ring to 45°. The inside upright extends from the perineum to three inches

FIG. 295.—Fixation Appliance for Thomas' Knee Splint.

FIG. 296.—Thomas' Knee Splint Applied. (Children's Hospital Report.)

FIG. 297.—Appliance for Adjusting the Length of the Thomas Knee Splint. (Burrell.)

below the sole of the foot. When the ring at the bottom is used the outside upright extends from half-way between the crest of the ilium and the top of the great trochanter to three inches below the sole of the foot. In measuring for the splint the circumference of the thigh at the groin should be measured and allowance made for padding the ring. The length of the uprights and the places on the ring where the uprights should be attached should be measured. These uprights should be so placed as to be in the same plane as the shaft of the femur.

The bar at the bottom of the splint can be utilized as a means for using traction if adhesive plaster is applied to the leg and webbing sewn

to the lower ends; the webbing straps are buckled tightly around the bar, and a certain amount of traction can be exerted. The idea of using traction is not in accordance with the views of the inventor of the splint. The leg can be fixed by means of bandages which pass around the leg and splint or by means of leather bands attached to the splint and lacing around the leg. With this splint applied, the patient sits in a ring sup-

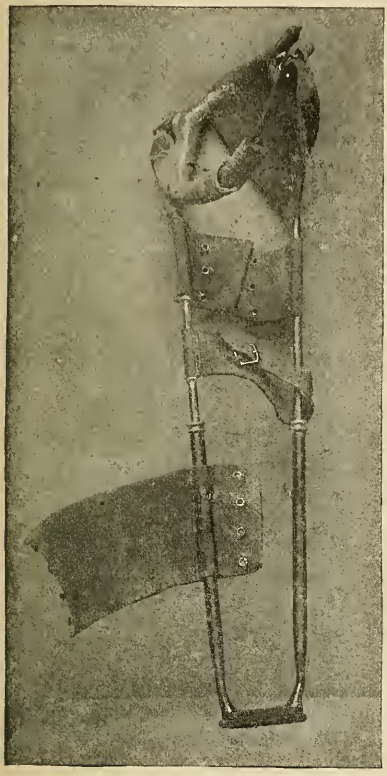

FIG. 298.

FIG. 299.

FIGS. 298 and 299.—Thomas' Knee Splint with Leather Lacings. Part of ring cut away. (Children's Hospital Report).

porting the perineum, while uprights run below the foot and bear the body weight. The protected limb can then be fixed by means of the bandages or leather lacings just spoken of.

In cases requiring less rigid protection and in the case of adults the inner half of the perineal ring is cut away and from the two extremities of the cut ring is slung a leather perineal band on which the patient rests in the same manner as in a hip splint. In very acute cases a stiff bandage to the knee in addition to the Thomas splint contributes better fixation than is possible with the splint alone.

For convenience it is often desirable to change the length of the splint,

and this can be done by the addition of a simple arrangement devised by Burrell. The uprights are made of two parts, the upper one passes in the lower, which is a hollow rod; a thread is cut in the upper rod and a nut screwed on it; by setting the nut at a higher or lower point, the upright is practically lengthened or shortened, while the inner rod is prevented from dropping out of the outer hollow rod by means of a screw which passing through the outer rod catches the inner rod and holds it firmly. The diagram shows the construction of the appliance (Fig. 297).

Fig. 300.—Thomas' Splint with Inner Part of Ring Cut Away, fitted as a Convalescent Splint. (Children's Hospital Report.)

The Thomas splint is slung from the shoulder by means of a strap, and the well limb is raised by means of a cork, wooden, or steel patten. Crutches are not generally necessary in connection with the Thomas splint.

When the condition of the limb has improved so much that pain and sensitiveness are absent or in mild cases the Thomas splint can be shortened, and the ends slotted into the sole of the shoe at such a place that the splint is too long for the heel to touch the ground, and in this way the patient walks about suspended largely by the perineal ring and bearing but little weight on the diseased joint. Then gradually after some months the use of the splint may be discontinued.

Slight cauterization, blisters, and iodine may be of assistance in the slighter cases; but in severer forms of epiphyseal ostitis more radical measures are needed. The introduction of the actual cautery into the bone tissues softened by ostitis has seemed to the writers to have a beneficial effect in some cases in stimulating the development of a cicatricial granulating tissue, but only in connection with mechanical treatment. Subcutaneous and intra-articular injections have not in the writers' hands proved of much benefit.

Treatment of Complications.—Flexion of the knee is the most common and the most troublesome complication of tumor albus. It is usually associated, when it occurs, in the early part of the disease with an acutely

sensitive condition of the joint, but later in the history it may come on insidiously and without pain.

The means of straightening a knee-joint flexed by acute disease may be classified as follows:

1. By traction in the line of the deformity applied (*a*) in bed; (*b*) while the patient goes about.

2. By means of apparatus forcibly straightening the leg; such as the Billroth splint, the Thomas knee splint, etc.

3. By simple fixation by means of a succession of plaster-of-Paris bandages.

4. By straightening under ether.

1 (*a*). In sensitive cases it may be necessary to confine the patient to bed. Traction by weight and pulley can be applied to the leg by means of adhesive plaster applied below the knee, the leg being supported by a firm cushion under the knee arranged so that traction comes in the line of the deformity. After a diminution of the spasm, which follows very soon upon the application of traction, the limb can be made straight gradually and fixed in a straightened position, and ambulatory treatment can be begun.

1 (*b*). *Traction in the line of the deformity* can be applied to the limb while the patient goes about, by one of several appliances which are more or less expensive. The best splint is one already alluded to, similar to the protection splint described for hip disease.[1] It is furnished with a perineal band which takes the body weight off of the leg, and at the knee is a lock joint which can be set at any angle. The bottom of the splint goes far enough below the foot to protect the limb from jar in walking, and ends in a traction bar. The splint is set at an angle corresponding to the angular deformity of the affected knee, and traction is made upward above the knee by means of adhesive plaster attached to the thigh and buckling on to the splint, and extension is made downward below the knee by a plaster extension pulling down to the traction bar at the bottom of the splint. The leg is fixed in the splint by leather lacings for the thighs and calf, which are adjusted after the extension is tightened. A simpler apparatus has been described by H. L. Taylor,[2] made of plaster-of-Paris and serving the same purpose except that it does not allow weight bearing on the affected leg.

2. *Correction by Means of Apparatus Forcibly Straightening the Leg.* —The Billroth splint is an efficient means of overcoming the deformity in cases in which the patients can be kept under observation. A plaster bandage is applied to the limb in which are incorporated two jointed iron strips attached to broad plates. The bandage is allowed to harden and then the front over the knee is cut out and at the back where it has been

[1] Lovett: Orth. Trans., vol. vi. [2] H. L. Taylor: Orth. Trans., vol. vii., p. 53.

purposely made quite solid, a transverse division of the plaster is made. Into this slit are inserted wedges of increasing size until the leg is straight. The splint has to be watched or it will cause sloughs, as it exerts considerable pressure.

The Thomas knee splint can be used to correct deformity; the bandage being applied in front of the thigh and the knee and behind the calf. By tightening them, the limb can be forced into a corrected position. This is the method advocated by Mr. Thomas, but in the hands of the writers it has in many cases at once started an acutely sensitive condition of the joint. For this reason, the appliance should be used with great care as, if injudicious force is used, an acute stage of arthritis can be readily brought about. With proper and skilful adjustment of the bandage, proper pressure on the back of the tibia can be exercised; but if too great pressure is exerted on the lower part of the leg, and too little on the tibia, the head of the tibia may be crowded against the end of the femur and the ostitis increased.

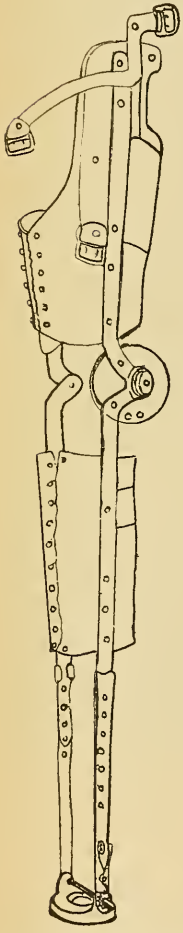

FIG. 301. — Splint for Traction on Knee at any Angle.

A simple wire splint is useful in correction of this deformity in the class of cases in which the sensitiveness is not great. It consists of a wire splint to which the thigh is attached; the leg is pulled upon especially behind the head of the tibia, thereby avoiding the uncomfortable results of exerting the straightening force wholly from the lower part of the leg.

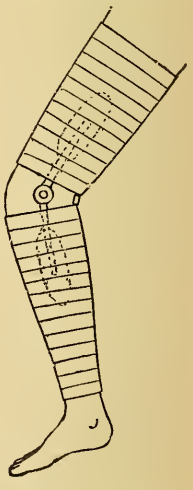

FIG. 302.—Billroth's Splint for Straightening the Knee.

3. *Reduction of Flexion by Fixation Bandages.*—A very simple way to straighten a knee-joint acutely flexed by disease, when apparatus cannot be afforded or is impracticable, is by simple fixation of the knee-joint by means of a series of plaster-of-Paris bandages. These should be applied to the knee in its deformed position without any attempt to extend it. It will be often found in the lighter cases that the limb can be made straighter at each successive bandage, so great is the sedative action of complete

fixation. It is hardly necessary to add that no weight should be borne upon the limb during the process of straightening.

4. *Forcible Reduction of Flexion.*—With regard to the straightening of the knee in acute cases under an anæsthetic it is not a measure to be adopted unless it is impossible to afford time for gradual straightening either in bed or while the patient goes about. Pain is generally occasioned by the proceeding, which is often the cause of an exacerbation of the disease. In cases without adhesions the knee is easily put in a correct position with the use of little or no force under complete anæsthesia.

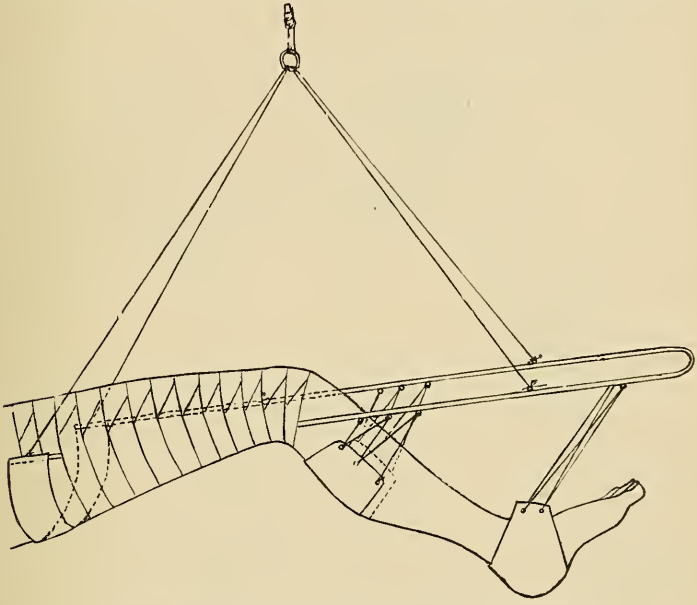

FIG. 303.—Wire Splint for Gradual Correction of Knee Flexion.

If the leg is allowed to remain in the flexed position, angular ankylosis will probably occur as shown in the figures. When firm adhesions have been formed at the knee-joint, correction by means of appliances will be found tedious, painful, and sometimes impossible, and generally forcible correction of some sort will be necessary to break down the adhesions. One way is to break down the adhesions by forcibly flexing the leg, and then by forcible extension to straighten it. The danger of rupturing the popliteal artery, which has occurred, is in this way diminished. Many appliances have been devised to give greater power in forcible correction. One procedure not requiring the use of apparatus is as follows: The patient is placed upon the floor upon the back and the surgeon stands over the patient holding the flexed knee with both hands, the fingers being placed under the popliteal space. The whole weight of the sur-

geon's trunk can be thrown upon the end of the lever furnished by the patient's leg, the hands of the surgeon, pulling upon the popliteal space, furnishing resistance. After the limb has yielded and the adhesions are broken, it can be straightened if the patient is turned upon the face; a downward force being applied to the heel, resistance being furnished by a cushion placed under the patient's knee. When subluxation of the tibia is present it must be corrected. This cannot be done so well by this method as by the instrumental method to be described. After correction, the limb should be well surrounded with sheet wadding and a

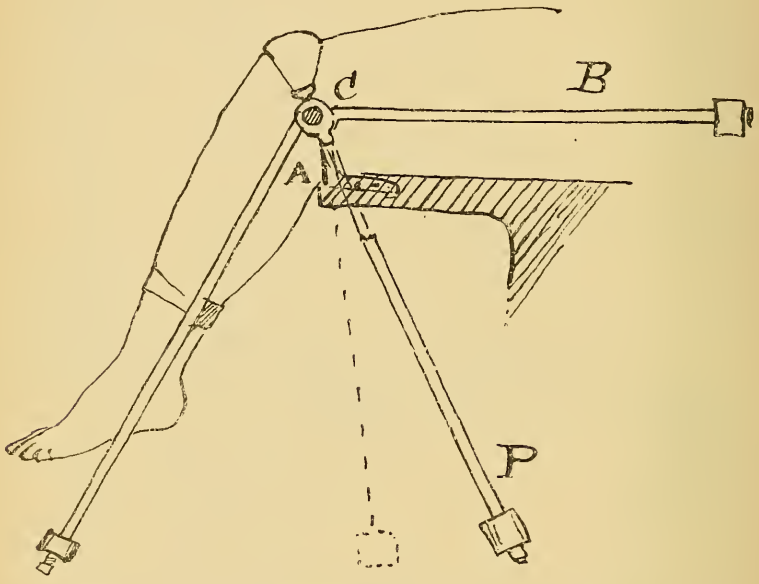

FIG. 304.—Pendulum Appliance for Straightening the Knee. The pendulum *P* is adjustable at the socket *C*, where the balanced bar *B* plays on *A*, attached to a stool.

stiff bandage applied, the limb being held straight until the plaster has become hard. The procedure is sometimes followed by pain, and opiates may be necessary for a few days. Such measures are not required except in resistant cases. The dangers incurred by this procedure are not so great as would be supposed. The danger of rupture of the artery can be avoided by care. Separation of the epiphysis of the femur may take place, but is cured by the fixation requisite to treatment, and should not occur if the force is carefully applied. Fracture of the femur and tibia can be avoided by care.

If the deformity, flexion, remains uncorrected in severe ostitis of the knee-joint, a subluxation of the tibia backward takes place, due to the contraction of the ham-string muscles. This is due in part to the spasm

of the ham-string muscles, which have pulled the tibia backward, but chiefly to the fact that owing to adhesions the flexed tibia is unable to slide forward over the condyles of the femur, as happens in normal extension. Attempts to straighten the leg simply crowd the anterior edge of the tibia into the condyles. To obviate this the head of the tibia should be pressed forward and upward to the same degree that the leg is raised.

The most efficient method of accomplishing this is by the use of the apparatus shown in the figure called by Goldthwait,[1] who modified it from the original apparatus, the "genuclast."

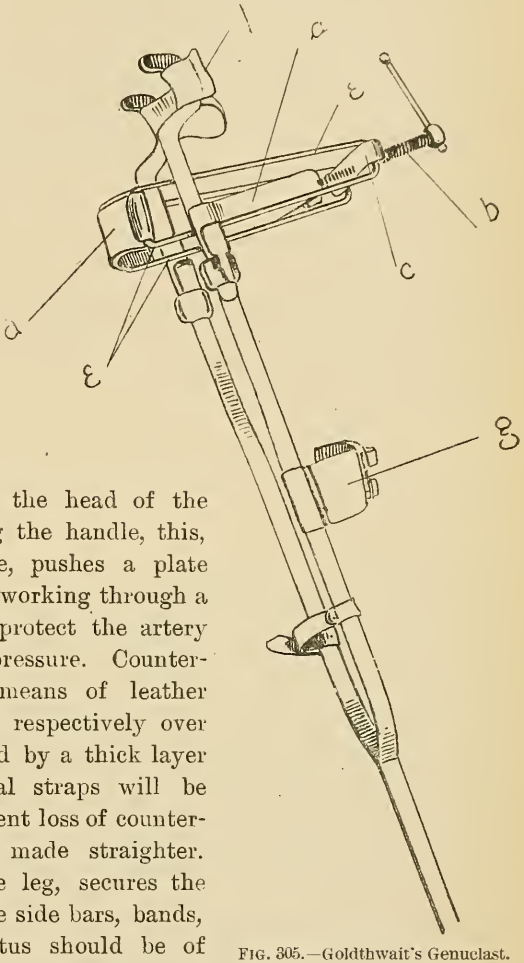

FIG. 305.—Goldthwait's Genuclast.

Pressure forward on the head of the tibia is exerted by turning the handle, this, by means of a screw force, pushes a plate forward against the tibia, working through a band. The calf muscles protect the artery and nerve from injurious pressure. Counter-pressure is secured by means of leather straps, which are passed respectively over the knee and leg, protected by a thick layer of saddler's felt. Several straps will be needed at the knee to prevent loss of counter-pressure, as the limb is made straighter. Another strap, under the leg, secures the lower part of the leg. The side bars, bands, and plate of the apparatus should be of strong steel.

The apparatus is put on the limb in a flexed position (after rupturing adhesions by forcible flexion if that is needed), the head of the tibia is pushed forward as far as is advisable, and, by means of the end of the appliance, which serves as a handle, the leg is extended; the pressure forward of the head of the tibia can be increased, and the counter-pressure regulated if necessary, by loosening such of the straps as exten-

[1] Boston Med. and Surg. Jour., September 7th, 1893.

sion of the limb may tighten too much. In some cases the reduction may be accomplished at one time, while in others successive applications of the apparatus are necessary. Adhesions of the patella to the front of the femur may constitute an obstacle to reduction without cutting. The treatment of cases resisting this method will be considered in the section of this chapter on operative treatment.

Experiments on the cadaver which were conducted by one of the writers at the Harvard Medical School, through the courtesy of Drs. C. B. Porter and T. Dwight, showed that by means of this appliance the tibia could readily be pushed forward to any desired extent. On normal joints, the tibia can be pushed forward to a considerable distance without rupturing the ligaments.

In general correction of flexion deformity under ether is the best method except in slight cases.[1]

Abscess.—The treatment of peri-articular abscess is the same that is recommended for the treatment of abscess at the hip. They are generally superficial and do not dissect about between the muscles to the extent that hip abscesses often do.

Operative Treatment of Tumor Albus

The operative measures to be considered are:

(1) Excision.

(2) Arthrectomy.

(3) Amputation of the leg.

(1) *Excision of the knee-joint* is to be undertaken in those cases in which conservative treatment has failed to arrest the progress of the disease; in which originally the disease is too extensive to warrant conservative treatment; in which the general health is failing and the disease failing to improve under efficient conservative measures. In adults it is to be undertaken earlier than in children, as the progress of the disease is in the former less favorable than in the latter.

Excision is inferior to conservatism as a treatment of knee-joint disease, because the mortality rate is higher and the functional results are not so good.

Excision of the knee is also performed to correct the deformity caused by bony ankylosis at an angle of flexion.

Mortality.—Lossen,[2] analyzing 586 cases of knee-joint resection done for tuberculosis or its resulting deformity,[3] found the results to be as fol-

[1] Report City Hospital, Boston, fourth series; Bull. et Mem. de la Société de Chir., vol. v., p. 461.

[2] Lossen: Deutsch. Chir., Leipsic, Bd. 29.

[3] Hitzgerad: Cent. f. Chir., 1888, 49, p. 919; Heinke: Inaug. Diss., Bonn, 1888; Neugebauer: Deutsch. Zeit. f. Chir., xxix., 1889, p. 379; v. Zeuge Manteuffel: *Ibid.*, xxix., 1889, p. 113; Schlüter: *Ibid.*, xxx., 1890, p. 285; Bothe: Beiträge zur klin. Chir., Bd. vi., 1890, p. 253; Krenz: Inaug. Diss., Würzburg, 1891.

lows: 439 (74.9 per cent) healed; 59 (10.1 per cent) unhealed; 50 (8.5 per cent) amputated; 38 (6.5 per cent) died.

In 384 cases in which the end results could be traced one to fourteen years after operation the results were as follows: 274 (71.3 per cent) remained healed; 46 (12 per cent) still had fistulous openings; 18 (4.7 per cent) were unhealed; 10 (2.6 per cent) were amputated; 36 (9.4 per cent) died.

In 329 cases tabulated by Phelps[1] in which the operation was done antiseptically there were 31 deaths (9.4 per cent), practically the same as in Lossen's group. Considered by age the results were as follows.

	Mortality.
Under 5 years,	38.9 per cent.
From 5 to 10 years,	16.2 "
10 " 15 "	17.2 "
15 " 20 "	30.1 "
20 " 25 "	39.4 "
25 " 30 "	37.0 "
30 " 40 "	41.5 "
Over 40 years,	52.6 "
The average of all being,	29.8 "

It would be fair to assert that in patients between five and twenty, the mortality from the operation, *near* and *remote*, would not be far from ten per cent, being less rather than more than this percentage.

Statistics in regard to the ultimate results of conservative treatment of disease of the knee are unfortunately of little value as a guide in the consideration of proper treatment of disease of the knee-joint; it may be said, however, that conservative treatment in children gives most excellent results in cases which can be watched[2] and treated for a long time.

The functional results after excision are, however, decidedly inferior to the results after conservative treatment. Ankylosis is to be hoped for after excision and is complicated by a tendency to flexion of the apparently ankylosed joint. In 130 cases analyzed by Hoffa there were 14 cases of slight flexion and 30 cases of severe flexion noted when the end results were considered. This of course is a very serious matter and should make the surgeon very careful about removing splints before there is reason to believe that firm bony ankylosis is present. This generally occurs after apparent union has taken place and the patient has been discharged from immediate supervision.

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[1] Trans. N. Y. State Med. Soc., 1886, p. 586.

[2] Centralblatt f. Chirurgie, No. 49, December 8th, 1883; Deutsche Zeitschr. f. Chir., 1885, Bd. 21, Heft 4.

It may be said with regard to the amount of shortening after excision in cases in which the epiphyseal lines are saved that it is likely to be only moderate, although even then it is more than after conservative treatment. In the cases of Hoffa[1] in which both epiphyseal lines had been removed by operation, the shortening was extreme, *e.g.*, 8 inches in 10 years, 3 inches in 2 years, etc. When only one line is removed and the one in the other bone left, there is shortening, but less; 5 inches in 6 years, 2 inches in 1½ years, etc. When both epiphyseal lines were saved the cases showed much less tendency to progressive shortening; inside of 2 years after operation it never exceeded 1¾ inches, and in the worst case of all it was only 4 inches and a fraction after 6 years, while many older cases showed less shortening.

It would not be fair, however, to dismiss the subject without adding that severe tumor albus without resection may cause serious arrest of growth in the bones in cases which heal. Nine such cases are reported by Caumont in which it ranged from ⅓ of an inch to 4 inches. The shortening after extensive excision is far greater in general than after a spontaneous cure. König's rule is most valuable in this regard: "Saw off inside the extent of the cartilage."

The operation of excision of the knee-joint is performed as follows:

The leg should be carefully prepared for an aseptic operation. The use of the Esmarch bandage and tourniquet is advisable. The joint is opened by one of the anterior incisions in common use, the periosteum and muscular attachments are cleared from the ends of the bones, the ligaments are cut, and the articular end of the femur protruded through the incision and as much as seems desirable sawed off. In the same way the tibia is cleared and protruded as a safeguard against injuring the popliteal vessels. It is well not to saw quite through to the posterior aspect of the bones, but to saw nearly through and then to break off the slice with a periosteum elevator.

The femur may be dovetailed into the tibia by cutting a concavity in the tibia with a butcher's saw and cutting the femur to fit into it. It is not an easy matter to do this and it adds much to the difficulty of the operation. In any case the patella should be removed if it is diseased, or if it has been divided in the operation the halves should be sewed together with silver wire or catgut. As to drainage, there is no need of the posterior counter-opening made by some surgeons, for drainage is perfectly good if the incision begins far enough back on the leg.

It is impossible to say how thick a section should be removed from the ends of the bones. In adults it matters not whether the section goes beyond the epiphysis so long as all the diseased tissue is removed. In children only very exceptionally is one justified in crossing the epiphy-

[1] Arch. f. klin. Chir., 1885, iv., 32.

seal line. It is best at first to remove a very thin section, just enough to take all the articular surface of both bones, and then to remove another section if the disease is very extensive, or if only foci of disease are seen to scoop them out extensively with a sharp spoon.[1]

It is of the utmost importance to attend carefully to the plane of section which the saw makes in removing the articular surfaces. If these planes are ever so slightly oblique the whole axis of the limb is distorted and the line of weight-bearing is wrong and tends to cause angular deformity at the knee. In the femur the plane of section should be parallel to the articular surface and not perpendicular to the shaft of the bone, which would make it oblique at the joint. As soon as section of the bones has been made, the new surfaces should be placed in contact and the line of the limb carefully observed.

To secure fixation the bones may be wired together or fastened to each other by nails or pegs of ivory or bone. Any of these methods are likely at any time to prove unsatisfactory; but at times they will be found to be of assistance. Another method is to fix the limb without the use of nails or wire. A wire posterior splint may be used. In general, plaster of Paris forms the most satisfactory splint put on over a heavy antiseptic dressing, the bones having been fixed accurately in position by some of the means mentioned and the limb after that handled very carefully. The only objection to it is that in the profuse discharge of serum which takes place necessarily from so large a wound within the first twenty-four hours, the plaster is likely to be stained through and may have to be changed. But if a sufficiently heavy dressing is put on, this will ordinarily not happen to any extent, or if it does a light dressing can be applied outside to protect the stained spot. Occasionally the plan is useful to dress the limb after operation in a heavy dressing and on the next day to redress it and apply the plaster.[2] In this way one may be almost sure of a dressing which can be left on almost indefinitely, provided the operation has been aseptic.

There are two precautions to be observed in putting the leg up in splints or in plaster; first, the tendency to eversion, and second, the tendency to dropping backward of the head of the tibia. With moderate precautions these deformities may be avoided. When the bones are wired together, if the holes which are bored in the tibia for the insertion of the wire are placed well backward and the corresponding holes in the femur well forward, much will be done to counteract this backward displacement of the leg upon the thigh.

The late after-treatment of excision requires no comment. The only danger that exists is that weight may be borne upon the limb too soon, before firm bony ankylosis may have occurred. It is much the wiser

[1] Cent. f. Chir., 1887, p. 440. [2] Brit. Med. Journ., April 2d, 1887.

course to have the patient wear a perineal crutch (in the form of a Thomas knee-splint) which shall prevent bearing any weight on the leg until several months after operation. If this precaution is neglected, permanent flexion of the limb is likely to occur or a lighting up of the original disease.

Excision of the Knee for Angular Ankylosis.—When excision of the knee is done for angular ankylosis, the only modification of the operation

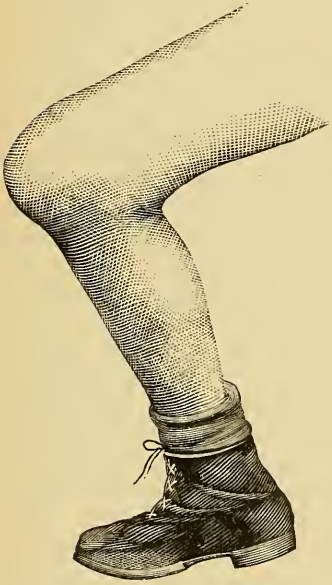

FIG. 306.—Angular Ankylosis of Knee.

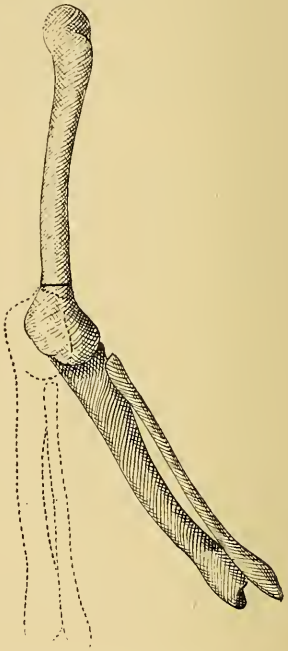

FIG. 307.—Osteotomy for Deformity with Ankylosis. (After Hoffa.)

which is necessary is the removal of a wedge of bone large enough to allow the ends of the bone to come together, so that the angularity is obliterated.

The knee is exposed as for simple excision, except that a more extensive flap is made, and then a wedge of bone is sawed out, of the required size to allow the knee to be straightened. The after-treatment is the same as in an ordinary excision. A simple method suffices to show the size of the base of the wedge to be removed. If the leg is laid on the side previous to operation and traced in outline on a large sheet of paper and the tracing of the leg is cut out, a wedge of the paper may be removed from the cut-out piece where the angle occurs. The removal of this piece, if it is of proper size, allows the paper leg to be straightened.

A paper wedge of the proper size shows the size of the wedge of bone which must be removed to straighten the leg.

Supracondyloid osteotomy of the femur is also to be mentioned as a means of correction in angular deformity of the knee, especially when the ankylosis is not complete, yet when correction cannot be obtained by non-operative measures. The advantage of this method lies in the fact that any motion remaining at the joint is not destroyed as it must be in excision. Its disadvantage is that the condyles of the femur are necessarily displaced forward to form an angle with the shaft. A linear or wedge-shaped osteotomy of the upper part of the tibia has been described by König for the same purpose.

Arthrectomy.—As a substitute for excision, what has been termed arthrectomy or erasion has been employed. The method has been also termed arthrotomy, but it differs essentially from a simple incision of the joint, and the term arthrectomy is preferable. Erasion is a misleading term and has not found general acceptance.

Arthrectomy[1] consists of the removal of all palpable and obvious portions of diseased tissue, whether in the synovial membrane or elsewhere, leaving what appears to be healthy tissue. Two advantages are claimed for this operation over excision: (1) That it does not interfere with the growth of the limb, and (2) that mobility of the joint may be preserved. It may be added that the latter is an exceptional event and not altogether so desirable or safe an ending under the circumstances as bony ankylosis. The objection to the operation is that it is not thorough, and oftener than excision fails to eradicate the disease.

The operation offers advantage over excision only in the case of children, and chiefly before the disease has made extensive progress. It is easy to see that, if any extensive disease of the bone is present, any measure short of thorough removal must necessarily fail. The operation is, therefore, not suited to cases in which there are many sinuses and bone enlargement, but to milder cases as a less severe operation than formal excision.

In the matter of risk there is little to choose between this operation and excision, for the immediate death rate under proper precautions is very small in both operations. The risk of operative tuberculous infection, alluded to so often in speaking of operations upon tuberculous joints, is present in arthrectomy as in excisions.

The operation itself may be described as follows: The joint is opened as in cases of excision and the tuberculous synovial membrane as far as possible should be dissected out; if carious spots are found in the bone, these foci should be removed by the curette or chisel. If the whole

[1] Volkmann and Ollier: Revue de Chirurgie, No. 3, 1885; Centralblatt f. Chirurgie, No. 9, 1885; Centralblatt f. Chirurgie, No. 48, 1884; Am. Jour. Med. Sciences, April, 1889, p. 369.

epiphysis is diseased, excision is of course unavoidable. Instances of excellent recovery with complete healing occur in cases of this sort, and success has followed the procedure in many cases in the practice of the writers. Strict asepsis is essential, as well as most thorough removal possible of all tuberculous tissue in the affected joint, necessitating sometimes complete dissection and removal of all of the synovial membrane, as well as careful curetting of the bone. The patella should be removed or left according to its condition.

The parts of the knee-joint to be most carefully investigated for diseased foci are the synovial pockets and the epiphyseal lines of the femur and tibia at their lateral aspects. Here one may find foci of tuberculous material extending into the epiphysis, without, however, in most cases crossing the epiphyseal lines.

The after-treatment should be like that of excision, except that wiring or nailing the bones together is not necessary, as the ligaments should be preserved so far as possible.

Flexion of the limb may follow arthrectomy as well as excision in cases in which protection to the joint has been discontinued too early, so that the after-treatment should be as careful and as prolonged as after excision of the joint.

(3) *Amputation.*—In cases of extreme disease of the knee-joint amputation of the thigh is necessary as a life-saving measure. As for the indications determining a choice between excision and amputation, it can be said that when the patient's reparative power is slight an amputation is to be preferred. The question is largely one of individual judgment; if excision is first tried and fails to arrest the disease and finally amputation has to be performed, the patient's chances are, of course, injured by the choice of excision in the first place. In the adult, extensive removal of the bones may be accomplished by excision without any danger of arrest of growth, and few patients can be brought to consent to amputation of a limb so long as any other method of treatment holds out the faintest prospect of relief. In children amputation should be deferred to the last moment and excision given the preference, unless the eradication of the disease would necessitate the removal of so much bone that a useless leg would result from that.

In children, therefore, the operation could be advised only when the joint was hopelessly disorganized and so much of the shaft of the long bones was evidently diseased that an excision was not practicable.

Summary.

The treatment of tumor albus should consist in *fixation* of the diseased joint by plaster of Paris or some suitable splint, with traction in cases in which the muscular spasm is very marked. If ambulatory treat-

ment is to be undertaken (which is almost invariably to be advised), *protection* is also necessary. This is furnished by the Thomas splint, a high shoe, and crutches, or by the use of a protection splint similar to the one used in hip disease, etc. Fixation can be discontinued at the close of the acute stage, but protection is advisable for a much longer time.

Excision is not an advisable method of treatment until mechanical measures have proved inefficient after a faithful trial, and the same is true of arthrectomy. Deformities should be corrected as they arise.

CHAPTER VIII.

OTHER DISEASES OF THE KNEE-JOINT.

Chronic synovitis.—Arthritis deformans.—Cysts of the knee-joint.—Bursitis.—Loose bodies.—Dislocation of the semilunar cartilages.—Dislocation of the patella.—Trigger knee.—Symptomatic affections.—Rupture of the quadriceps extensor tendon.

Chronic Synovitis.

Chronic serous synovitis is most often the sequel of the acute or subacute form. When it is the outcome of acute synovitis, the chief symptoms of that affection gradually subside, leaving, however, a joint partly full of fluid and disabled on that account. A recurrent subacute or chronic synovitis also results from the irritation caused by loose bodies in the joints, by displacement of the cartilages, and by slipping of the patella. These should not be overlooked in assigning a cause for any given case. When the affection does not originate in an acute attack, the earliest symptoms are, usually, impaired motion and pain with slight limp, and occasionally a loss of strength is complained of. The pain is not severe unless the joint is excessively used, and it is relieved by rest. Later, swelling, increased surface temperature, and redness of the skin may appear. Tenderness may not be marked, except in the acute stages. Generally, when no constitutional tendency to disease exists in simple chronic synovitis, the joint finally becomes normal.

Synovitis of the knee-joint may remain indefinitely in a subacute condition, with a slight amount of effusion, accompanied by thickening of the synovial membrane, or a large amount of serous effusion may take place, with slight inflammatory symptoms.

Long-continued chronic synovitis of the knee, or a repetition of acute attacks, may lead in time to a relaxed condition of the knee-joint. Lateral mobility becomes evident and the muscles fail to control the joint with their former accuracy. It is this result which is to be feared, as well as permanent stiffness in long-continued chronic serous synovitis.

Diagnosis.—Chronic synovitis with effusion is evidenced by the enlargement of the joint and the fact that in the knee the patella is lifted by the effusion, and floats. In examination for this the fingers of both hands should encircle the extended limb firmly in front, above, and below the patella, thus confining the effusion to the space directly under the

patella and over the intercondyloid depression on the femur. The forefinger of one hand then lightly but sharply presses on the patella, which can be felt to descend and hit the femur. This matter of fully extending the leg and grasping it is of much importance, as otherwise a small effusion may escape detection.

The affection most likely to be mistaken for chronic serous synovitis is chronic inflammation of the prepatellar bursa, "housemaid's knee." Here, however, the swelling is local and clearly in front of the patella, instead of being behind it, and the patella does not "float."

Chronic tumor albus beginning as an epiphysitis cannot always be differentiated from chronic serous synovitis.

Hysterical joint disease is often located in the knee, and in its symptoms may simulate chronic synovitis very closely; but objective signs are absent. There is no effusion, although there may be tenderness, and the whole aspect of the affection is more like ostitis than synovitis in its symptoms of local tenderness and severe spasmodic pain.

Treatment.—In chronic synovitis, thorough fixation is needed in the early or more acute stages, with compression.

Compression is most readily applied to a knee-joint by means of a thin rubber bandage wound about the limb; bandages of elastic cloth can also be used. Dried and compressed sponge, bandaged firmly about the limb, will expand when wet, and in this way compress the tissues of the joint effectively; or the knee may be thickly covered with sheet wadding, outside of which is applied binders' board made pliable by immersion in hot water, and the whole bandaged firmly.

Hot air and massage are often of much value by improving the local circulation and promoting the absorption of synovial effusions or its results. Twists and sudden jars are to be avoided, and protection (crutches or splints) is advisable in the stage of convalescence if the attack has been at all a severe or a protracted one.

Antiseptic irrigation or incision of the joint have been advocated for chronic synovitis of the knee-joint. On account of the great resistance which many cases of the affection offer to the ordinary methods of treatment, one turns readily to any means of relief which may be tried when the methods by compression, etc., have failed. The fluid in the joint may be withdrawn by aspiration and its place partly filled by the injection of a few ounces of either carbolic-acid solution or one of corrosive sublimate; the latter is probably attended with less risk. It is better that in such cases the joint should be incised and thoroughly washed with hot water or weak corrosive solution.

Arthritis Deformans.

The knee is one of the large joints most frequently attacked by arthritis deformans, or rheumatoid arthritis.

Symptoms.—Pain and stiffness are the symptoms at first complained of. Pain may involve the whole joint, but is more commonly localized in a tender spot over the internal condyle of the femur. It varies very much in amount, and is likely to increase in intensity in consequence of exposure to cold or wet, when some indiscretion in diet has been committed, or as a result of over-use of the affected leg. At the beginning of nearly all cases, pain occurs in acute attacks accompanied by local heat, with tenderness and swelling. The acute symptoms subside, to return again and again, leaving behind them each time a certain amount of structural change in the joint in the form of synovial thickening, bony enlargement, and peri-articular infiltration. In other cases the affection progresses slowly and insidiously without definite acute attacks.

At first the swelling may be due to synovial effusion which marks the beginning of the affection in many cases; in other instances synovial distention does not occur. Ultimately the outline of the joint becomes indistinct and a boggy or hard swelling envelops the knee. Stiffness at first passes off with movement, but later in the disease it becomes permanent, often to the point of ankylosis. Creaking in the diseased joint is an early and characteristic symptom and reveals only too plainly the nature of the affection.

This phenomenon is due chiefly to hypertrophy of the synovial fringes, which are rubbed together when the joint is moved. It is also probable that the same sensation can be produced without any structural change by mere dryness of the articular surfaces.[1]

In general, the tendency of the affection is toward greater and greater impairment of the joint motion, with wasting of the muscles and atrophy of the skin, so that in the advanced stages one can see a stretched and shining skin tightly drawn over the deformed and distorted joint.

The outlook is unfavorable, unless the disease is taken in the early stages; not that life is likely to be shortened, but that serious disability of the joint most often results.

Treatment.—During the acute attacks above alluded to, when pain is caused by walking and movement, and heat and tenderness are present, rest is very strongly indicated along with counter-irritation, which is best applied in the form of blisters over the joint or tincture of iodine painted on abundantly. Hot-water douches, and compression by an elastic bandage or, better still, by a Gamgee dressing of millboard and sheet wadding, are also of much benefit.

[1] Cent. f. Chir., October 15th, 1887.

A few days will generally suffice to quiet the acute symptoms. During the quiescent stage, the best local measures are massage, counter-irritation, hot douching, the hot-air bath, and protection of the joint by a warm covering, such as a flannel bandage; moderate exercise is also to be regarded as a therapeutic measure, when it is not attended by discomfort. If pain is excessive, one has to face the dilemma of continuing motion which is excessively painful or of allowing the patient to rest and keep the joint still, by which process one is likely to favor the stiffening of the joint, if it is continued for too long a time. For short periods, however, there is no risk, and sometimes much to be gained by complete rest to the affected articulation.

Much importance in the matter of treatment is to be attached to general measures, and when it is practicable, a visit to some well-chosen health resort is likely to be of benefit. The benefit of the waters and baths in these places, along with the change of scene and a carefully regulated diet and régime, often accomplish much.

Such a measure of treatment, however, is out of the reach of the majority of patients, and one has to consider much more often the method which is likely to be of most use at home.

The diet should be carefully regulated.

Water, which will act as a diuretic, should be taken in measured quantity daily (from one to two quarts at least). Lithia waters are useful, but in many of the natural waters the quantity of the drug contained is so small that it is better to resort to an artificial water containing a definite amount of the drug. A very useful addition to the water taken at meals is a teaspoonful of the imported Vichy salt, or of one of the artificially prepared effervescent Vichy salts sold here.

It is desirable to take a hot bath at least twice each week, to promote secretion by the skin, and the bowels should be kept active by saline laxatives. Hydrotherapy properly practised is of value.[1] General and local massage is a resource of the greatest value, and a mild galvanic current is also of much benefit as a promoter of proper circulation.

Less is to be expected in the matter of drugs than from general hygiene and treatment. Salicin or salicylate of soda in ten-grain doses, three times daily, often has a marked effect in controlling the affection, and an alkaline diuretic is almost a necessity. Lithia, or the salicylate of lithia, at other times accomplishes more than salicylic acid does. Arsenic is sometimes useful to a marked degree, but iodide of potassium is not generally of much benefit. Tonics should be given in the form of iron or quinine, or strychnine, if the general condition is not good or if the appetite flags.

When ankylosis of the knee in a faulty position has resulted from

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[1] Baruch: "Hydrotherapy," New York, 1898.

rheumatoid arthritis, brisement forcé is to be tried for its rectification, as described for the correction of ankylosis after tumor albus. It is not, of course, to be expected that motion will be present in the joint in its new position, for the structural changes must have already been extensive to have induced the deforming ankylosis, yet some motion may be preserved in the joint. Excision of the knee may be required in cases which are so firmly ankylosed as to resist the surgeon's attempt at straightening.

When, however, the ankylosis is the outcome of a simple rheumatic synovitis occurring in the course of an acute or chronic attack of rheumatism, forcible manipulation may break up the adhesions which have caused the joint stiffness and restore a certain amount of permanent motion to the articulation. These cases are to be distinguished from the ankylosis of arthritis deformans by the fact that in the former the joint is practically normal in outline and there is no bony enlargement of that or the other joints described as a characteristic of arthritis deformans.

Cysts of the Knee-Joint.

The occurrence of cystic swellings in connection with the larger joints, especially the knee-joint, was called attention to by Baker.[1] These swellings are found, from time to time, in the neighborhood of the knee-joint, generally in the popliteal space. At first there is nothing to suggest their connection with the joint in any way, for the cyst may be at a considerable distance from the joint. There may be no fluctuation to be obtained between the joint and the cyst, nor can the fluid from the cyst be pressed into the joint; in fact, there may be no evidence of effusion in the joint.

In this case it is difficult to believe that any connection exists between the cyst and the articulation, but Baker pointed out the almost universal connection of these cysts with the joint cavity.

As a rule, there is, or has been, a certain amount of effusion into the joint which has escaped into the neighboring bursæ or into a hernial protrusion of the synovial membrane, while in other cases it seems clear that the affection of the joint was secondary to a bursitis.

Riese[2] has advanced the view, however, that these swellings are true cystic tumors of degenerated fibrous tissue and not outgrowths or hernias of the capsule. He bases this view on the existence of an obliterating endarteritis of the vessels supplying them. The affection is found most often in early and middle adult life.

The diagnosis from bursitis is often difficult.

Extirpation of the sac is the only treatment likely to be of use.

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[1] "St. Bartholomew's Hospital Reports." vol. xiii., p. 245; vol. xxi., p. 177.

[2] Cent. f. Chir., 1898, p. 585.

Bursitis of the Knee.

The various bursæ about the knee may become inflamed and give rise to disability of an obscure nature.

Housemaid's Knee.—The most common seat of this affection is in the prepatellar bursa which lies over the patella and part of the ligamentum patellæ. This is not, as a rule, one well-defined sac, but consists of three layers of bursæ more or less well marked and generally in communication with each other and at times with the knee-joint. The three layers are classed by Bize[1] as subcutaneous, subaponeurotic, and subtendinous.

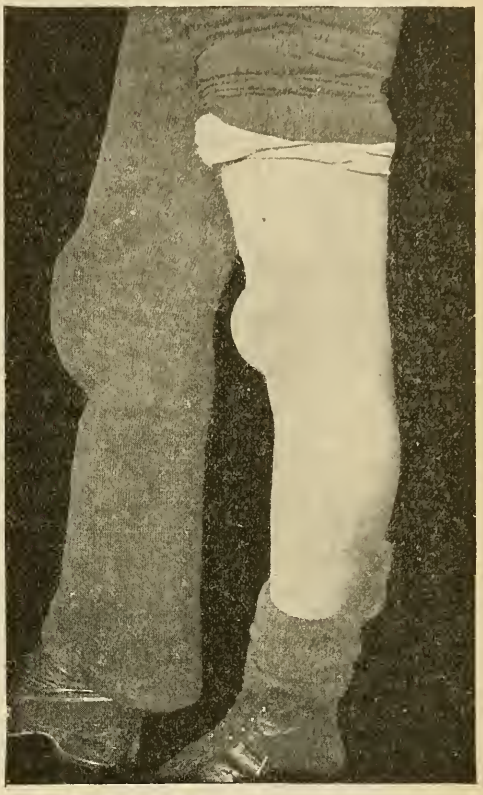

Fig. 308.—Prepatellar Bursitis.

This affection is found chiefly in persons whose occupation leads them to spend much time in kneeling. The acute affection is brought about by over-use of the knee and is characterized by slight swelling, sensitiveness on pressure, and discomfort in flexing the knee, which is localized at the site of the bursa. Palpation shows a more or less distinct swelling, which lies over the patella and which is rendered more tense by the flexion of the joint. In the acute stage it is likely to be mistaken for synovitis of the knee-joint, especially as the inflammation, if neglected, tends to spread and the swelling may become more diffuse and burrow around the joint; although the chronic enlargement of the bursa is sometimes primary, more often it is the outcome of a series of acute attacks. Fluctuation is clearly present, and the swelling is more sharply localized to the region in front of the patella than in synovitis. In the chronic stage of the affection, heat, sensitiveness, and discomfort are ordinarily absent, except a slight feeling of stiffness in complete flexion of the leg.

[1] Journ. d'Anat. et de Phys., Paris, xxxii., 1896, p. 85.

For diagnosis, one must depend upon the facts that the swelling is entirely in front of the patella, that the patella does not float, that the joint is not affected, and that the occupation of the patient in some way has produced continual slight injuries of this region. Although the acute affection shows a tendency toward recovery under rest, the chronic affection does not have this tendency and is likely to continue unabated.

Suppuration occurs in both acute and chronic varieties in a certain proportion of cases; and it is generally in consequence of some depleted condition of the system or some local aggravation. The inflammation of the bursa occasionally occurs in connection with gout, rheumatism, or syphilis.

Treatment.—The acute affection, unless too far advanced, ordinarily yields readily when the limb is placed in the extended position upon a ham splint, and the constant irritation of walking is avoided. Painting the skin with iodine and the application of pressure either by sheet wadding and bandages, or by an elastic flannel bandage, is of much assistance in allaying the inflammation; a few days or weeks in the milder cases will ordinarily reduce the inflammation. In old cases this treatment has little or no effect. If, however, the bursitis has reached the stage of suppuration, incision affords the only hope of relief.

In chronic bursitis, either the bursa may be aspirated and pressure afterward applied, or the knee may be let alone. The discomfort is so slight that occasionally patients very much prefer to have nothing done. The most satisfactory treatment in chronic cases is to lay the entire bursa open by a crucial incision, and either dissect out the tough fibrous sac which will be found there, or having laid it open, scrape it out very thoroughly with a curette. Any other measure is useless, when the inflammation has reached the stage of suppuration.

Bursitis of the Deep Prepatellar Bursa.—The affection of this bursa presents certain characteristic symptoms often difficult to differentiate from those of synovitis. This bursa lies beneath the ligamentum patellæ next to the tibia. It rises as high as the upper edge of the tibia and is triangular in shape, the apex of the triangle being downward near the tubercle of the tibia. This bursa practically never communicates with the knee-joint.[1]

The inflammation of this bursa is described under various names, one of them being *Pseudarthrose du Genou.*[2]

The peculiar symptoms of this affection are pain in complete extension of the leg, referred to the tubercle of the tibia; pain and tenderness referred to the patella tendon; apparent enlargement of the tubercle of the

[1] Lovett: Boston City Hosp. Reports, 8th series, p. 345.

[2] Dubreuil: Annales d'Orth., Paris, September, 1890; Archiv f. klin. Chir., 1877, xxi., 132; "Traité de Path. ext." (Follin), iii., 19; Pitha and Billroth: "Chirurgie." iv., 1, Heft 2, p. 242; Feraud: Thèse de Montpelier. 1880.

tibia, and bulging at the sides of the ligamentum patellæ. The affection may be mistaken for inflammation of the superficial pretibial bursa[1] or for the inflammation of abnormal bursæ in this neighborhood.[2] Careful examination will usually differentiate it from synovitis of the knee-joint.

The treatment does not differ from that of housemaid's knee except that bursitis of the deep pretibial bursa is more obstinate.

The inflammation of other bursæ about the knee-joint presents no peculiar symptoms, and the existence of the affection is made evident by the presence of a fluctuating swelling at the site of a bursa.

Loose Bodies in the Knee-Joint.

The pathology and formation of loose bodies has already been considered. It has been stated that nine-tenths of all the cases occur in the knee-joint. In a majority of cases the first intimation to the patient that anything is wrong is that while in the act of walking or stooping he is seized with such agonizing pain in the knee that he may fall to the ground, in many cases overcome with the sensation of faintness and sickening pain. At times this pain subsides almost immediately, and the patient is able to walk within a few minutes; but at other times the joint remains fixed in a position of more or less flexion, and any attempt to move it is attended with very severe suffering. In any event, such an occurrence is apt to be followed by an attack of synovitis lasting several days. Up to this time the joint may have been normal and given no trouble, or it may have been the seat of chronic inflammation. These attacks are likely to be repeated without any assignable cause. On manipulation of the joint with the fingers, it is often possible to detect a loose body which shifts its position and is found first in one part of the joint and then in another. The most common spot where they can be detected externally is in the pouch over the external or internal condyle of the femur. They are felt as smooth slippery bodies under the skin, which evade the fingers' grasp with surprising readiness. Occasionally they may be found over the tibia inside the ligamentum patellæ, and when one of these substances has been found it is desirable to see if others are present in the joint. Sometimes it is impossible to detect any loose bodies from the outside, and the history of the case must be depended upon to establish the diagnosis. In some cases the attacks are of very frequent occurrence, while in others it is only at intervals of several weeks or months that the joint gives any trouble.

With repetition of attacks the joint becomes more tolerant and the synovitis less severe. In cases in which arthritis deformans is present as the cause of the loose bodies, the history of the attacks is less typical.

[1] Monks and Richardson: Boston Med. and Surg. Jour., December 18th, 1890.

[2] Delore: Gaz. Heb. de Méd. et de Chir., June 2d, 1894.

The patient, however, experiences in a measure the same sudden catching of the joint, and movement of the affected knee is painful, restricted, and attended with a particularly distinct grating.

Finding a movable body which can be slipped from place to place by manipulation establishes the diagnosis.

In cases in which the loose body cannot be found, one must depend largely upon the history; making, however, frequent examinations under different conditions with the hope of ultimately detecting the foreign body.

FIG. 309.—Charcot's Disease of Knee. (Weigel.)

The diagnosis between internal derangement of the knee-joint and a loose cartilage is often a difficult one to make, and dependence must be placed chiefly upon tenderness in a very small spot over the head of the tibia as establishing the probable occurrence of dislocation of one of the semilunar cartilages. In the majority of cases of loose bodies, on the other hand, it is possible ultimately to detect externally their presence, as causing the trouble.

In cases in which the loose body gives but little inconvenience and is kept from passing between the ends of the bone by a knee-cap it may not be advisable to undertake operative treatment. In other cases, especially in arthritis deformans, the joint may have become so much impaired by the disease that even if a foreign body were removed little would be gained. In the great majority of cases, however, inasmuch as the disease occurs in otherwise healthy persons, mostly young adults, any operation which does not entail serious risk is advisable.

Woodward was able to collect 105 cases in which a direct antiseptic incision of a joint had been made for the removal of a foreign body. In 104 of these the knee was the joint affected, and 92 of these were for the removal of loose cartilages. In 1 case the foreign body proved to be a sarcoma, in 1 a fibroma, and in 1 a lipoma. In 2 cases nothing could

be found, and in 1 of these adhesions behind the back of the patella were forcibly broken up. There was but 1 death in these 105 operations, and that was due to phlegmonous erysipelas, so that the asepsis of this operation is, at least, doubtful. The same may be said of 2 other cases in which suppuration necessitated amputation of the thigh, while stiffness of the affected joint resulted in 3 cases; in 1 of which 400 loose cartilages had been removed, in another 24, and in a third 4. In 4 other cases besides these, slight impairment of motion was reported.

In complicated cases, of course, there is a possibility of more or less resulting stiffness. The list of 105 cases is given in full in Woodward's paper.[1] The operation is performed as follows:

The loose body having been found, a needle is passed through it from the outside to steady it, and it is then cut down upon by careful dissection until it is exposed and removed. After the removal of the body originally detected, the joint should be carefully examined to see if others are present. In a case in which continual trouble was caused, an exploratory incision into the knee-joint would be attended with very slight risk and might be of great benefit in discovering the presence of pedunculated loose bodies which escaped detection from the outside. There is, of course, a slight tendency to the re-formation of these bodies after one or more have been removed.

With regard to the treatment of the synovitis which is caused by the "catching" of the limb, a few days' rest will be sufficient to quiet it. The patient soon acquires the habit of straightening the limb himself, after the attack, when it is fixed in a flexed position.

Dislocation of the Semilunar Cartilages.

(Hey's Internal Derangement.)

The term "internal derangement" had its origin in the term given by Hey in 1803[2] describing the condition. The condition was, however, previously described by William Bromfield in 1753.

The affection is nearly always traumatic in origin and consists in the tearing loose from its tibial attachment of the internal or external semilunar cartilage. The internal is the one most frequently displaced. This is probably for two reasons: first, because it has less mobility on the tibia than the external, and secondly, the motion most likely to displace it forcibly is outward rotation of the tibia on the femur, or what has the same effect, inward rotation of the femur on the tibia. It must be remembered that the knee is not a strictly hinge joint, but that in exten-

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[1] Boston Med. and Surg. Jour., April 25th, 1889.

[2] Hey: "Practical Observations in Surgery," 1803; W. Bromfield: "Chirurgical Observations," 4 cases, vol. ii., 1753.

sion the leg rotates outward upon the thigh, especially at the end of extension when a quick outward rotation of the tibia occurs, locking the leg in complete extension.

A sudden wrench or twist in slight flexion is the accident most often causing displacement of these cartilages.

The symptoms are in a measure similar to those described under loose cartilage. The patient by some violent muscular effort or by some sudden twist as in kicking football or falling from a horse or carriage, wrenches the knee and finds it impossible to fully extend it, and walks with it bent in the way described, suffering much pain.

In some instances much tenderness can be found over the inner tuberosity of the tibia where none was present over the outer tuberosity; and Marsh photographed a case which shows externally a depression over the situation of the internal semilunar cartilage. This sudden locking of the joint, so far as extension is concerned, is almost the only characteristic symptom of internal derangement; but generally on examination one finds a protrusion of one of the semilunar cartilages. This establishes the diagnosis, and a sharp attack of synovitis of course follows such a severe injury to the joint.

The most marked cases happen after some serious wrench to the joint. Nevertheless, cases occur in which the cartilage is perhaps only relaxed, and in these a much less painful locking of the joint arises. The affection is masked in many patients by the severity of the acute synovitis which follows the injury, and the true character of the accident may not be learned for a long time afterward unless its history is most carefully inquired into. One occurrence of the accident predisposes to subsequent attacks. Lateral mobility of the knee is likely to exist in cases of long standing.

Internal derangement of the knee-joint affects, for the most part, persons between twenty and fifty years of age; men are much more frequently affected than women; it occasionally occurs in children.

Patients who are liable to the displacement soon learn the manipulation of reduction themselves. The knee should be bent to its fullest extent, the tibia should then be drawn away from the femur as far as possible, to separate the joint surfaces, at the same time rotating the tibia inward or outward as the internal or external cartilage is displaced, and then the leg should be extended quickly but not forcibly to its fullest extent, while the surgeon manipulates with the thumb the situation of the semilunar cartilages, especially if any undue prominence should be felt. An anæsthetic is very often necessary or advisable. The reduction in exceptional instances cannot be effected, but commonly, and especially with the use of an anæsthetic, reduction takes place easily and a distinct click is heard in many cases.

The cartilage may after reduction become united to the tibia by its

former attachments or it may remain loose to cause further attacks. It may be simply torn from its tibial attachments and remain attached as before at its two ends, or it may also be torn across in the middle, and the free end may cause trouble by acting practically as a loose body. Finally, entire detachment of the torn piece may occur, in which case it becomes a loose body of the cartilaginous class.

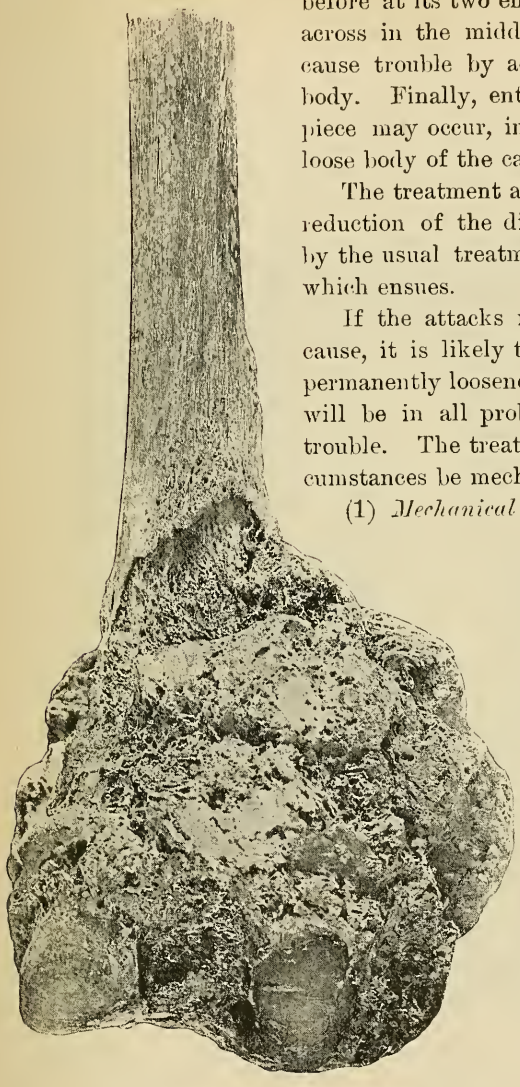

FIG. 310.—Tumor of Femur Involving Knee.

The treatment after the original accident is reduction of the displaced cartilage, followed by the usual treatment for the acute synovitis which ensues.

If the attacks recur, especially on slight cause, it is likely that the cartilage has been permanently loosened from its attachments and will be in all probability a source of further trouble. The treatment may under these circumstances be mechanical or operative.

(1) *Mechanical Treatment.*—Although the use of knee-caps with pads beside the patella, elastic bandages, etc., may prove of use in preventing in part future attacks, they can hardly be recommended as a form of treatment on account of the great inconvenience attending their use, and the fact that they are to be regarded as palliative rather than curative.

The mechanical treatment advocated by Shaffer for this condition will be described in the following section (page 351).

(2) *Operative treatment* is, as a rule, surer, quicker, and more acceptable to the patient. The joint is opened inside or outside of the ligamentum patellæ according to the cartilage displaced, by a transverse or vertical incision. If the cartilage has simply been detached from its coronary attachment and not torn across, the detached portion should be stitched to the capsule

and other fibrous structures covering the head of the tibia. If the cartilage has been detached and also torn across, the loose portion should be removed. Whichever operation is performed, the joint should of course be explored and the wound closed. Fixation should follow for about six weeks, followed by massage and passive motions.

Dislocation of the Patella.

Dislocation of the patella or slipping patella is likely to occur either spontaneously or for very slight cause in certain young girls with lax

Fig. 311.—Patella in Normal Position.

muscular fibre and a feeble development, and boys are only exceptionally attacked.

In consequence of some slight twist of the leg, as in dancing, rising from a chair, going upstairs, or some similar motion, an excruciating pain is felt in the knee, and the person either falls in consequence of faintness, or finds herself unable to use the leg. Very often the patient herself hears a cracking sound when the dislocation occurs. The patella

is found almost always dislocated outwardly, sometimes twisted so that its lateral edge rests against the front of the femur (vertical luxation of Malgaigne). The reduction of the dislocation is very simple and is very soon learned by the patients themselves. The leg is fully extended and the patella gently pressed back into place until it assumes its proper

FIG. 312.—Patella Dislocated.

place with a click, or often it slips back of its own accord when the leg is straightened. An attack of synovitis follows, as in the case of loose bodies, but the joint soon acquires a tolerance so that each succeeding attack of synovitis becomes less.

The cause of the affection seems to be, in most cases, the lack of tonicity in the extensor muscles of the thigh, or the elongation of the ligamentum patellæ, but very commonly the former.

After many attacks of dislocation the patients complain of a certain sense of insecurity in walking which in severe cases may amount to a distressing disability, limiting the patient's ability to walk or engage in active occupation.

Congenital dislocation of the patella is considered under Congenital Dislocations.

Mechanical Means for Securing a Slipping Patella.—There are many devices for retention of a slipping patella. The elastic knee-cap, which is frequently recommended, will be found of little service; it presses the patella downward upon the femur without exerting pressure on the sides of the patella. If, however, an elastic knee-cap is split in front and furnished with lacings or straps, and if felt pads are sewn upon the sides of the cap at such places as would exert pressure upon the sides of the patella, an arrangement is furnished which, when properly adjusted, will give a serviceable support in lighter cases, allowing motion at the knee. A more efficient and less comfortable support can be made by taking a cast of the limb, and upon this moulding a leather knee-cap, which can be laced about the lower thigh, knee, and leg. This does not permit bending at the knee, but exercises some pressure on the sides of the patella and entirely prevents its slipping. It, however, favors the development of atrophy, but is of value after a severe attack followed by effusion, and is a means of retention of the patella until the strained ligaments have recovered their strength.

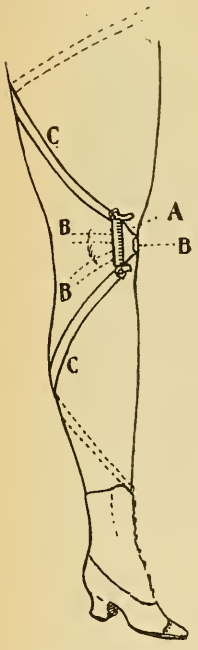

FIG. 313.—Strap to Restrain Slipping Patella. *A*, Strip of leather to which a rubber tube is secured, pressing against outer edge of patella; *B*, a piece of adhesive plaster secured to the leather and applied to the outer side of knee; *C C*, webbing strap fastened to waist and boot and by buckles to leather piece *A*.

The following steel appliance will be found of service: It consists of two uprights, hinged at the knee, extending from the middle of the calf to the middle of the thigh on each side of the limb, and connected with cross-pieces above and below. To these are attached at the level of the middle of the patella semilunar plates, which are of such a shape and are bent in such a way as to press upon the sides of the patella. They are covered with padding and leather. If leather straps pass diagonally from the uprights to buttons upon the top and bottom of these plates, an adequate amount of side pressure will be secured. Two straps from underneath the knee prevent the apparatus from falling forward, and the straps mentioned prevent the apparatus from slipping backward. It is essential that this appliance should not remain in a bent position, as the pressure at the sides of the patella would in that case be diminished. To prevent this a spring is furnished connecting the upper portion of the upright with the lower portion, with sufficient strength to force the appliance into a straight position, but allowing bending of the knee by muscular effort.

Massage and Electricity.—It is manifest that no cure can take place

except through the development of the muscles or improvement in the strength or length of the ligaments. In certain cases reliance can be placed upon the natural development in the growth of the patient, and it is simply necessary for recovery to protect, during the growing period, the ligaments from the additional strain of the frequently displaced patella. Massage and electricity are manifestly indicated in all cases.

Operative treatment consists in the removal of an elliptical piece of the front of the capsule of the joint internal to the extensor tendon and a stitching together of the edges of the opening, thereby tightening the inner part of the capsule. This operation has been performed by Bijardi,[1] Gavin[2] (quoted by Bradford), Perkins, of Kansas City (traumatic), Bradford,[3] Lovett,[4] and others. Goldthwait has transplanted the ligamentum patellæ inward in a case with knock-knee, and in a later case the tubercle of the tibia was transplanted inward with its attachments.[5]

In resistant cases a vertical incision outside of the patellar tendon must also be made to allow the patella to be pulled into place by the tightening of the capsule on the inner side.

Mechanical Treatment of Elongation of the Ligamentum Patellæ and Dislocation of the Semilunar Cartilage.—A form of mechanical treatment for the correction of elongation of the patellar tendon has been advocated by Shaffer, which is applicable to cases of recurrent dislocation of the semilunar cartilages. This has for its basis the supposition that an elongation of the ligamentum patellæ is a causative factor in at least some of the cases of dislocation of the cartilages.[6] This factor was noticed by Hey as follows: "If there is any difference from its usual appearances, it is that the ligament of the patella appears rather more relaxed than in the sound limb. . . . The patient himself cannot freely bend nor perfectly extend the limb in walking, but is compelled to walk with an invariable and small degree of flexion."

Shaffer in ten cases of slipping cartilage described an abnormally high position of the patella on the affected side, being from one-quarter of an inch to an inch higher than on the sound side. The treatment advocated and found efficient by Shaffer is the application of an apparatus to the thigh, leg, and foot, allowing only the hinge motion, thus preventing, at least in large measure, the slight rotation at the knee occurring in extension of the leg. The apparatus also is arranged by a stop joint at the knee to prevent complete extension of the knee. It consists of an outside upright attached to the boot and reaching to the upper part of the

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[1] N. Y. Med. Record, April 20th, 1895.

[2] Unreported.

[3] Trans. Am. Orth. Assn., vol. viii., p. 227.

[4] *Ibid.*, vol. viii., p. 237.

[5] Annals of Surg., 1899.

[6] N. M. Shaffer: Read before College of Phys., Philadelphia, March 11th, 1898.

thigh, and an inside upright reaching from the upper thigh to the upper part of the calf, and a pad is placed over the inner aspect of the knee. The object of this treatment is by preventing harmful motions and positions for some months to produce a reunion of the cartilage to its proper attachments and a return of the ligamentum patellæ to its proper length.

Trigger Knee.

The so-called *trigger knee*, described also as genou à ressort or schnellendes Knie, is characterized clinically by a disturbance in extension of the leg. Extension is normal until about 160° is reached, is then completed with a snap and forcible jerk, during which there is also outward rotation of the tibia. It is not connected with any disease of the knee-joint nor any obvious abnormality save looseness of the ligaments. The cause is evidently a disturbance of the movement of the semilunar cartilages, particularly the external, which is caught between the joint surfaces and suddenly freed, producing the jerk described. The prognosis in children is good, depending upon tightening of the ligamentous structures with or without treatment. Mechanical treatment is apparently not necessary, at least in children.[1]

Symptomatic Affections of the Knee-Joint.

Certain malpositions of the foot may result in pain, irritation, and even synovitis of the knee-joint, when the knee structurally is normal and affected only secondarily. Such disturbances occur in flatfoot, pronated foot, and shortening of the gastrocnemius muscle. The mechanism of their production has been worked out by Dane. The consideration of this subject will be taken up later.

Rupture of the quadriceps extensor femoris may occur either above or below the patella. Loss of the power of extension of the leg at once results. Recovery without operation is slow and, as a rule, incomplete. Suture of the separated ends is indicated.

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[1] Trans. Am. Orth. Assn., vol. x., p. 40; Thiem: Monatsch. f. Unfallkh., 1896, p. 182; Rölen: *Ibid.*, 1898, 377; Nasse: Deutsche Chir., Lief. 66, Heft 1, p. 299; Cotton: Journal Boston Society Medical Sciences, May, 1899.

CHAPTER IX.

DISEASES OF THE JOINTS OF THE ANKLE AND FOOT.

Ankle.—Synovitis.—Tuberculosis.—Tenosynovitis.—Functional affections.—*Metatarso-phalangeal articulations.*

Diseases of the Ankle-Joint.

Synovitis.—Acute synovitis of the ankle-joint is common, most often as the result of injury and rheumatism. Owing to the anatomical relation of the parts, effusion within the joint can take place only to a limited extent. Peri-articular swelling is a marked and early symptom, because of the fact that the soft parts next the joint are not hidden under a thick layer of muscle or fat.

In simple chronic synovitis the foot may be held extended beyond a right angle, and at the tibio-tarsal angle in front more or less prominence is found when the capsule is distended with fluid. This is limited above and below, and sometimes the swelling can be seen to have raised the anterior tendons, and it is sometimes possible to detect fluctuation here. There is also likely to be a slight swelling at the sides of the tendo Achillis. In simple chronic synovitis motion is generally but little limited and not very painful, or but slightly so, so that a weakness and stiffness of the joint with occasional pain are the only symptoms complained of.

The tendons and ligaments are usually involved in severe sprains of the ankle.

Acute traumatic synovitis of the ankle is treated either by rest and fixation, by massage, or by hot-air baths or by a combination of these.

When walking is painful in the convalescent stages or when the sprain has become chronic, it is desirable to support the arch of the foot in the manner to be described in speaking of affections of the foot. Flat-foot at times results from sprains of the ankle.

Chronic synovitis is most likely to be the result of the acute condition which for some reason has not been properly recovered from. In cases of long standing the circulation and innervation of the foot and leg become impaired and swelling and congestion occur in connection with pain, tenderness, and impaired use. Malpositions of the foot may occur, the most common being a limitation of dorsal flexion. Under these cir-

cumstances the dorsal flexibility must be restored, the arch of the foot supported, and measures employed to stimulate the circulation and re-

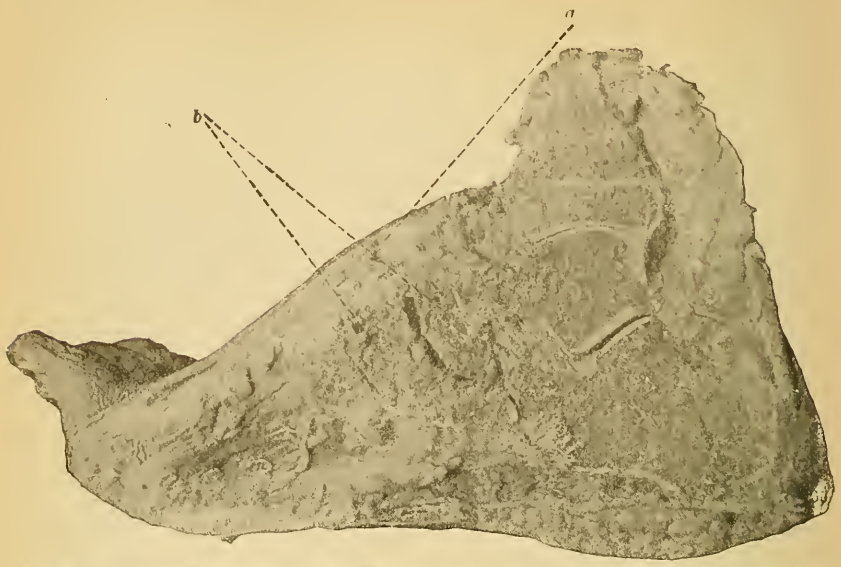

FIG. 314.—Tuberculous Ankle-joint. Diffuse tuberculosis of tarsus. Primary focus lost in the area of destruction. *a*, Tuberculous infiltration of soft parts; *b*, tuberculous softening of tarsal bones. (Nichols.)

store it to its normal condition. Among these measures may be mentioned as most important the gradual resumption of the use of the foot under proper protection.

Chronic Tuberculous Disease.—The seat of the disease may be in the articular end of the tibia or in the astragulus; and other adjacent bones

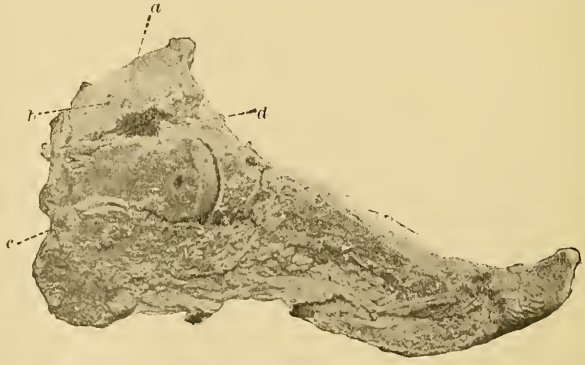

FIG. 315.—Tuberculous Ankle. *a*, Lower end of tibia; *b*, tuberculous cavity in tibia; *c*, tuberculous disease of calcis; *d*, tuberculous disease of astragalus. (Nichols.)

may be involved secondarily or simultaneously, as the os calcis, the scaphoid, cuboid, and cuneiform bones. Affection of these latter bones may also exist alone.

The affection is not, as a rule, a painful one, but in certain cases it may assume this type, and night cries may accompany an exquisite tenderness of the whole joint to pressure and motion. Tenderness, as a rule, is present over the joint capsule in front, and perhaps under the malleoli, and swelling and heat are invariable accompaniments of the affection. Muscular rigidity is marked in most cases.[1]

Lameness is an early and a marked symptom. Sometimes it is produced by the pain which weight-bearing causes in walking, but more

FIG. 316.—Tuberculous Disease of the Ankle.

FIG. 317.—Ankle-joint Disease at an Early Stage.

often by the muscular stiffness which will not allow the ankle-joint to bend. The swelling consists of a boggy infiltration of the soft parts around the ankle, along with a distention of the joint capsule by gelatinous granulations. In character it is œdematous. This swelling is uniform around the ankle, except when an abscess is pointing on one side. The depressions in the contour of the ankle in front and behind the malleoli disappear in the swelling. The foot in affections of the ankle-joint usually assumes a position with the toes pointing downward, and in chronic cases with the foot slightly rolled outward (in the position of equino-valgus). This, however, is not the only malposition, for the foot may assume the position of pure talipes calcaneus. These malpositions are brought about by the abnormal tonic muscular contraction, and these deformities yield of themselves and the foot returns to its normal position when the irritation is quieted in the joint by proper treatment.

[1] Annals of Anat. and Surg., May, 1882.

Wasting of the thigh and calf muscles occurs. Abscess may occur.

When the disease attacks the medio-tarsal or tarso-metatarsal joints, the anterior part of the instep appears swollen and is hot and tender. Motion at the ankle is but little restricted, but motion in the anterior part of the foot is attended by pain and is usually lost. The location of the affection is evident from examination. If the os calcis is attacked

FIG. 318.—Swelling of the Joint in Disease of the Ankle.

primarily it is manifested by the same symptoms of local inflammation without any symptoms referable to the ankle-joint. In many cases the treatment is too soon discontinued after sprains, and a teno-synovitis or subacute inflammation of part of the synovial sac may persist, and be accompanied by local heat and tenderness. It matters not so much how long after a sprain is found in the ankle-joint, local heat is a most important sign; it indicates the need of rest.

The recognition of disease of the ankle is dependent on the usual symptoms of limping, limitation of motion of the joint, stiffness, swelling of the joint, pain, heat, and tenderness. The prominence of these symptoms varies with the activity and extent of the disease.

Teno-synovitis gives rise to swelling around the tendons; there may

be some puffiness of the skin, heat, hyperæsthesia, and pain on certain movements of the foot; but extreme change in contour of the ankle is not present, and the pain is chiefly that of apprehension. In manipulating the foot, a creaking at the painful spot may be felt, and this spot itself is sharply localized and, as a rule, is not over the joint, but in the course of the tendons.

Functional Affections.—The most troublesome affections to diagnosticate from ankle-joint disease are the functional affections which result

FIG. 319.—Tuberculous Ankle. Advanced Stage.

often from sprains and injuries. Here it is not uncommon to find, in hypersensitive women chiefly, a limitation of motion of the ankle, with much pain on manipulation and pressure; there may be slight swelling left over from the injury, and the question to be decided is, whether any disease of the joint exists which can well be made worse if the patient goes about, or if it is purely a subjective affair which can be overcome by judicious management. In one case rest is indicated, in the other activity. The diagnosis of functional joint disease is considered in full in the proper place.

Again, it should be repeated, that one must depend chiefly upon the existence of the objective signs of ankle disease, rather than upon the patient's feelings; allowing, however, due weight to the history of the affection and the patient's sex and constitution.

Treatment.—The general principles of the treatment of chronic joint disease are nowhere more applicable than in ankle-joint disease, although they are, of course, modified by the anatomical conditions present.

Traction is not applicable as a mode of treatment, from the difficulty of applying it, so that one turns to fixation and protection.

Protection from jar is especially indicated—as will be readily seen, if it be borne in mind that in locomotion the whole weight of the body is borne at each step upon the comparatively small surface of the articulating portion of the astragulus. Fixation of the ankle in a stiff bandage while allowing the patient to walk upon the limb is a manifest error, as affording little or no real protection to the joint. Fixation is of advantage in the more acute stages of the affection, and is readily furnished by means of stiff bandages. A plaster-of-Paris bandage is the most convenient appliance, and should be carried above the knee so as to fix that joint also. Silicate and dextrin bandages are more durable, but more complicated in their application. Protection can be furnished either by means of crutches or, more thoroughly, by means of protective splints with perineal supports. Protective splints, described for the knee-joint, are useful in ostitis of the ankle. The Thomas knee-splint is generally the most available.

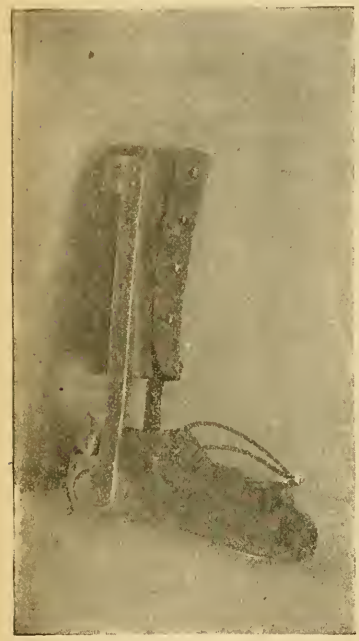

FIG. 320.—Fixation Ankle Shoe. (Children's Hospital Report.)

Unless the disease is far advanced, children who are in good condition, as a rule, do well under conservative treatment. Adults do not make such good progress; but conservatism should first be tried. If abscesses form, they should be incised and traced to their source, and if loose bone is detected this should be removed. If the foot assumes a malposition, this should be corrected; and this is best done by applying a plaster bandage to the foot in its malposition and quieting thereby the inflammation so much that in two weeks the malposition will be found less and an improved position can be gained. The general health should be carefully inquired into and appropriately treated. All these procedures may be grouped together and be said to complete the expectant method of treatment.

In a series of thirty cases of ankle-joint disease treated conservatively observed by Gibney[1] the results were as follows:

The minimum duration of the disease was 1 year.

[1] N. Y. Med. Rec., August 21st, 1880, p. 197; Am. Jour. of Obstet., 1880, p. 434.

The maximum duration of the disease was 6 years.

The average duration of the disease was 3 years and 3 months.

The average time of treatment was 1 year and 3 months.

In 19 cases suppuration was very extensive.

In 6 cases suppuration was moderate.

In 5 cases suppuration was absent.

The disease occurred in young children, the limbs were slightly shortened, and the calf was atrophied. Twenty patients did not limp at all, and 7 only slightly. There were one or two cases in which some deformity appeared in the foot after use.

The expectant plan fully carried out is justifiable in a large proportion of cases, and on the whole the results obtained are good. In cases of tuberculous disease of the ankle the decision of continuance of conservative treatment or the adoption of operative interference is one which is based largely upon the patient's age and the circumstances of attendant care.

There are three alternatives left if the expectant method fails. The mildest form of operative interference consists in curetting the sinuses and removing what diseased bone it is possible to reach. Occasionally it may be possible to scrape out a focus of tuberculous material in the os calcis, but in the tarsus proper it is rarely a satisfactory procedure. The second operation is a formal excision of the diseased bones. The third and most radical measure is amputation of the leg or foot.

Culbertson brought all excision records up to 1873. He tabulates 124 cases excised for disease. Of these, perfect results were obtained in 5.55 per cent. A useful foot in 60.18 per cent, and 2.77 per cent were not useful, and it was necessary to amputate the foot in 12.03 per cent of the cases. The mortality table states that, of the 124 cases, about 8.5 per cent died from the operation.

Culbertson's cases were reported before the days of antiseptic surgery. The long time then necessary for healing of the operation wound is, under present methods of wound treatment, much shortened, and suppuration is infrequent. Cases are being reported to-day with great accuracy and in fuller detail. Hence the great value to be attached to the reports of Connor's 108 cases. He found that in 10.53 per cent there were failures; 6.32 per cent could walk with a cane; 24.21 per cent could walk and not limp; and 47.37 per cent had good results. The foot is shortened and broadened; the ankle motions vary. The shortening of the limb varies, but is slight. In a few cases an osseous regeneration occurs. Connor finds that an excision of the whole or part of the tarsus is not much more dangerous than an ankle-joint amputation, and subsequent removal of the foot is possible if desired.

A series of eighteen excisions of the ankle-joint was reported by Scudder. These were hospital cases operated on at the Children's Hos-

pital and were cases in which the ultimate result was known. They were reported in 1889.[1]

The question arises, Will the disease in the foot cease if the bone is removed? It may be said that, if thoroughly removed in children, relapse is unlikely to occur. More relapses occur from partial operations and from gougings and scrapings than from any other cause. The earlier excision is done, and the more bone removed from the tarsus, the better is the result.

The operation should be performed by the subperiosteal method; the diseased tissue removed from the ends of the leg bones and the astragalus removed entire with the top of the os cacis, if diseased.

There are many modifications of the lateral incisions which are in common use, and other incisions radically differing; but of all methods preference must be given, in the opinion of the writers, to that of Kocher, which has proved eminently satisfactory in their experience when a formal excision is to be done.

The method is as follows: The foot is held at a right angle and a superficial incision is made along the outer border just below the external malleolus, reaching from the tendo Achillis to the extensor tendons. The peroneal tendons are dissected out, secured by sutures, and then cut by a second and deeper incision. The ankle-joint is opened very easily and the capsule along the anterior and posterior surfaces of the tibia is cut. The foot is then dislocated inward as far as is desired, and the joint can be inspected to any extent. After the diseased parts have been removed, the foot is reduced to its proper position, the peroneal tendons are united, and the wound is closed.

When the foot is dislocated, an admirable view is obtained of the interior of the joint.

The osteoplastic resection of Mikulicz[2] is a substitute for amputation in cases of very serious disease of the posterior bones of the foot.

The after-treatment of cases of ankle-joint excision is similar to the treatment of the others spoken of. Asepsis, and immobilization in a correct position are the requirements; and to this end infrequent dressings are very desirable. Plaster of Paris applied outside of a heavy dressing is very serviceable, as in knee-joint excision. An accurate and equally efficient splint is a wire posterior splint, which is made of a rod of "copper-washed iron wire" three-sixteenths of an inch in diameter, which is bent to fit the leg and padded except at the ankle, where it is covered with rubber tubing and can be rendered aseptic and incorporated in the dressing there. The rest of the splint is padded. One can also use an anterior wire splint. But whatever splint is used, the point about

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[1] Scudder: Orth. Trans., vol. ii., p. 53.

[2] Archiv f. klin. Chir., xxvi.; Med. News, December 3d, 1887.

Scudder's Table.

Number.	Sex.	Age.	First Symptoms.	Cause.	Operation.	Result as to Life.	Result as to Usefulness.	Cause of Death.	Time after Last Treatment when Examined.	Atrophy in Inches. Thigh.	Calf.	Foot.	Arc of Motion. Well.	Dis.	Condition of Joint at Time of Operation.	Number of Months of Expectant Treatment.
									Months.							
1	M.	3	1879	Caries.	Astragalus	R.	Fair.	Tuberculous meningitis.†	..	..	..	..	..	..	Healed.	
2	M.	2¼	1879	Caries.	Astragalus and curetted.	D.	.....	Tuberculous meningitis.	..	..	..	..	..	..	Not healed.	
3	F.	12	1884	Caries.	Cuboid; two outer cuneiform; head fifth metatarsal.	R.	.....	Tuberculous meningitis.*	..	..	..	..	..	..	Healed.	
4	M.	3	1886	Caries.	Astragalus.....	R.	.....	Tuberculous meningitis.‡	..	..	..	..	..	..	Not healed.	
5	M.	1½	1888	Caries.	Os calcis; curetted..	D.	.....	Septicæmia (?)	..	..	..	..	..	..	Not healed.	
6	M.	4	1887	Caries.	Astragalus	R.	.....	Tuberculous meningitis.§	..	..	..	..	..	..	Not healed.	
7	M.	3½	1887	Caries.	Astragalus	R.	.....	Dying; amyloid.	.	..	..	..	..	..	Not healed.	
8	F.	14	1880	Caries.	Astragalus	R.	Great.	....	9	½	1½	1¼	46°	20°	.....	10
9	M.	9	1883	Caries.	Expectant	R.	Great.	.....	6	1	1¼	⅝	67°	22°	.....	26
10	M.	22	1876	Caries.	Expectant	R.	Fair.	.....	13	..	2½	1¼	47°	39	.....	4–5 yrs.
11	M.	18	1880	Caries.	Proximal end of second metatarsal	R.	Great.	.....	9	1	1½	1⅝	45°	14°	.....	9
12	F.	13	1882	Caries.	Expectant	R.	Great.	.....	8	¼	1	½	46°	38°	.....	11
13	M.	7	1885	Caries.	Expectant	R.	Great.	.....	4	¾	1½	½	73°	32°	.....	12
14	F.	12	1887	Caries.	Complete excision ..	R.	Great.	.....	2	1	2	1	43°	29°	.....	Several.
15	F.	8	1887	Caries.	Astragalus	R.	Great.	.....	2	1	1½	¾	..	..	.....	Several.
16	M.	9	1887	Caries.	Astragalus	R.	Great.	.....	2	..	..	..	..	..	.....	Several.
17	M.	6	1887	Caries.	Complete excision ..	R.	Great.	.....	2	..	..	..	..	..	.....	Several.
18	F.	3	1887	Caries.	Portion of tarsus including astragalus .	R.	Great.	.....	6	Slight.			..	..	.....	Several.

* Died in 1887. † Died in 1881. ‡ Died in 1887. § Died two months after operation.

which one must be most careful is to see that the foot is at a right angle to the leg and in the same plane. For a long time after excision the joint should be protected from weight-bearing by the application of a Thomas splint, or some such appliance.

Metatarso-Phalangeal Articulations.—These joints are occasionally attacked as a result of injury. In chronic rheumatoid arthritis they may also be attacked. Inflammation of the metatarso-phalangeal articu-

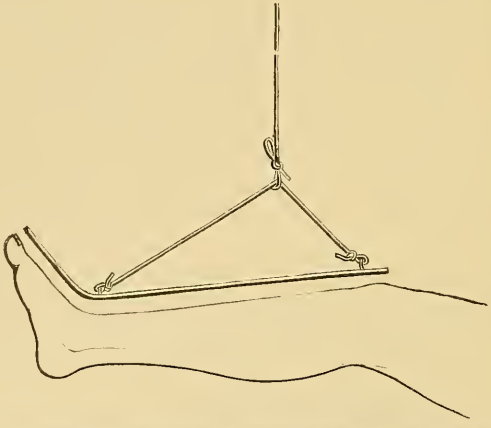

Fig. 321.—Form of Wire Splint for Treatment of the Ankle after Excision.

lation of the great toe takes place consequent on the distortion of the toe called "hallux valgus or in-toe," the result of imperfect shoes, and also secondarily to the affection well known as bunion. An ankylosis of this joint occurs in adolescents, probably a sequel to a long-continued subacute inflammation, the result also of imperfect shoes.

Nothing especial need be said of inflammation of the phalangeal articulations, except that they are not common. Excision of the smaller joints of the foot is rarely required. When it is necessary, however, it is done by any simple method which seems applicable.

CHAPTER X.

DISEASES OF THE OTHER JOINTS.

Shoulder-joint. — Acute synovitis. — Chronic synovitis. — Chronic tuberculous disease. —Bursitis and teno-synovitis.—Chronic rheumatoid arthritis.—Peri-arthritis.—Charcot's disease.—Synovial cysts.—Bursitis.—Treatment.—Excision of the shoulder-joint.—Habitual or recurrent dislocation.—Obstetrical paralysis.—*Diseases of the elbow.*—Synovitis.—Chronic tuberculous disease.—Stiffness of the elbow.—Treatment.—Excision of the elbow.—Arthrectomy.—*Diseases of the wrist.* — Synovitis. — Tuberculous disease. — Teno-synovitis. — Chronic arthritis deformans.—Treatment.—Excision of the wrist.—*Sacro-iliac disease.* —Pathology.— Etiology.— Symptoms.— Diagnosis.— Prognosis.— Treatment.— *Diseases of the phalangeal articulations. — Diseases of the temporo-maxillary articulations. — Diseases of the sterno-clavicular and acromio-clavicular joints. —Diseases of the articulations of the sternum.—Diseases of the symphysis pubis.*

Diseases of the Shoulder-Joint.

Acute synovitis of the shoulder occurs as the result of injury, rheumatism, etc. The physical signs of the affection do not differ essentially from those described in speaking of other joints. The acute arthritis of infants is occasionally observed in this joint, where it presents its usual characteristics.

Chronic synovitis of the shoulder is an affection existing either as a sequel of an acute attack, the result of some injury, or as a slow, persistent process, beginning with slight symptoms easily disregarded.

The earliest symptom to attract notice is stiffness, observed particularly in forced movements, as in placing the hand on the head, etc. Pain is a variable symptom.

A slight fulness about the joint may be detected at this time, the humero-pectoral groove being indistinct, and the depression below the acromion obliterated. Although an increase of surface temperature may often be detected, its absence is of little importance, the joint being so thoroughly covered. As the disease progresses, the case presents an exaggeration of the early symptoms; motion becomes more restricted, swelling increases as effusion takes place, the shoulder appearing broader, and elevations may replace the natural depressions. Atrophy of the deltoid and scapular muscles gradually occurs, but to a less extent than in the forms of ostitis. Pain is a symptom of varying severity. In gen-

eral, the tendency is toward resolution with more or less impairment of joint motion.

Chronic bursitis and *teno-synovitis* may exist and simulate closely chronic synovitis of the shoulder. But the stiffness is in the former only in the direction of certain movements, and the tenderness and swelling are chiefly confined to the affected structures.

Chronic Tuberculous Disease.—The general symptoms of ostitis of the shoulder differ in no way from those in the usual for mof this disease in other more commonly affected joints, except that stiffness of the joint and malpositions due to muscular spasm are less noticeable on account of mobility of the scapula. The disease is insidious, extremely chronic, prone to suppuration, and decided impairment of the joint is likely to result.

FIG. 322.—Shortening of Humerus; Lack of Growth from Early Epiphysitis. (W. P. Bolles.)

One of the earliest signs of this disease is pain of a dull aching character, which is usually aggravated at night, and is referred either to the joint itself, or to the middle of the arm near the insertion of the deltoid. In many cases this symptom is absent or very slight. A slight increase of surface temperature may be detected, but the thickness of the coverings of the shoulder-joint renders this uncertain. There will usually be found a tenderness, frequently localized over a small area, generally over the anterior surface of the joint, but sometimes on its posterior aspect. The patient instinctively holds the arm at rest, and attempts at passive motion provoke muscular spasm, and if the attempt is persisted in the humerus and scapula are seen to move together. The stiffness of the arm along with the swelling are the most characteristic features of the affection. Early in the disease a change in contour of the joint becomes apparent, which is due to enlargement of the head of the humerus as well as to muscular atrophy. When the swelling is due to effusion within the joint, the shoulder appears fuller and broader than normal, and this is seen best in looking down on the patient; the natural depressions in front of and behind the joint become either obliterated or are the sites of prominences.

If suppuration occurs, the patient complains more of pain, and the swelling increases. The prominence of the swelling will depend on the direction taken by the pus, but this will most often be found collected in the axilla, under the deltoid, or along its anterior edge. The subsequent course is slow, the result depending on the extent of the degenerative process, which may terminate soon after evacuation of the pus or continue to complete destruction of the head of the humerus.

The possible results are: recovery with a stiff joint (ankylosis), deformity and impaired muscular power, or entire destruction of the head of the bone; and in children later arrest of development of the humerus may result (Fig. 322).

Chronic Rheumatic Arthritis.—Next to the knee the shoulder is the most frequent seat of this disease, when it occurs in the monarticular form.

When one shoulder alone is affected the history of injury is usual, but in the polyarticular forms this is not so common.

The disease may first manifest itself to the patient as a slight attack of joint pain, tenderness, and stiffness, and from this condition pass into the slow chronic course, with occasional exacerbations, or it may begin insidiously. The amount of pain varies: it is more or less persistent, but not constant, and is dull and heavy and usually worse at night. Stiffness appears at this time with pain, at first only slight, and noticed in forced movements, when the arm is raised above the level of the shoulder. Both pain and stiffness are more noticeable after a period of rest.

From the appearance of these symptoms the disease is slow, extending over months or more before marked change occurs. As the disease progresses the muscles waste, and in severe cases to a very noticeable degree. A creaking sensation, both on active and passive motion, is almost always found by placing the hand over the joint. Later in the disease, when the characteristic osseous changes occur, the arm can be raised but a short distance from the side, and the loss of muscular power is great. Swelling independent of bone enlargement sometimes occurs, and is due to effusion within the cavity of the synovial membrane, but is not a common occurrence and usually appears late in the disease. When the changes in the joint have taken place a characteristic appearance of the joint is found. The head of the humerus is more prominent in front of the joint, while behind is a depression as if the head of the bone was displaced forward, while the shoulder droops.

Peri-arthritis of the Shoulder.—Duplay has described as *peri-arthritis* of the shoulder-joint a condition of stiffness not infrequently seen after comparatively slight injuries. Pain accompanies motion beyond a certain limit. Atrophy of the muscles is present, and at times there is some spontaneous pain. The arm may become of comparatively little use. The diagnosis of peri-arthritis is not based on pathological evidence,

and, judging from clinical analogy, it seems fair to infer that the affection may either be a bursitis or may include the synovial membrane, constituting a chronic synovitis as well as a peri-arthritis.

Gonorrhœal Synovitis.—The shoulder is not infrequently the seat of urethral arthritis, but this differs in no way in its course and symptoms from the same disease in the more commonly affected joints.

Charcot's disease occurring in the shoulder-joint is less common than at the hip, knee, or elbow, but it presents no especial characteristics in this situation, except that the head of the humerus and the glenoid cavity may be worn away; the latter in such a manner as to form a large hollow cavity.

Synovial cysts may rarely be noted in connection with the shoulder; *bursitis* and *enlargement of the bursa* beneath the deltoid and other bursæ about the shoulder may occasionally be seen.

Treatment.—In synovitis of the shoulder-joint with any active inflammation, the indication is simply for rest and fixation. These are readily secured by means of a sling and a bandage securing the arm to the side. It is important to mention that in chronic synovitis of the shoulder the weight of the arm dragging upon the joint structures may be a factor in keeping up the pain and irritation. Consequently in the shoulder the use of a supporting sling is necessary in these cases. Compression will be needed if there are swelling and effusion. Fixation should not be continued longer than there is subacute inflammation, and can be gradually discontinued; first discarding the bandage and retaining the sling, which can be discontinued later. So long as muscular irritability exists, rest is indicated. In these cases an increased arc of motion and diminished sensitiveness will usually follow a few days' rest of the joint, and permanent ankylosis is rendered less likely by the application of timely immobilization.

In tuberculous ostitis at the shoulder-joint, the indications for treatment are practically the same as those presented in chronic synovitis. Distraction is not indicated in disease of the shoulder, as, owing to the laxity of the joint, the weight of the dependent arm, if kept at rest, is sufficient to separate the humerus from the opposing bone surface of the scapular articulation. In painful cases, however, it might be necessary to apply traction for a time, by an instrument similar to the short Sayre splint figured for hip disease, or even by the weight and pulley traction applied during recumbency.

Monks has called attention to the advantage sometimes to be derived from supporting the shoulder in a position at right angles to the side of the body. This method may be of advantage by taking the weight of the upper extremity off of the shoulder, it relaxes the deltoid and other structures covering the joint, and the circumflex nerve and other deeply seated structures are relieved from pressure. The arm is either held in

this position by a plaster-of-Paris spica bandage, supporting the arm and encircling the trunk, or a platform splint may be constructed of wire, which takes its base of support from the side of the trunk and supports the arm by means of a platform running out from this. The method is of advantage in certain cases in which the ordinary position is not comfortable.[1]

The question of the use of forcible passive motion in the convalescent stage does not differ from the same question discussed in speaking of other joints. If the stiffness is due to adhesions, manipulation under an anæsthetic, followed by massage, etc., may be of value; but in the majority of light cases gradual passive exercises will suffice. Gentle, graduated, passive motion carried to the verge of being painful, with the use of electricity, is of great advantage in many cases of shoulders stiffened from a slight degree of chronic joint inflammation. If the stiffness above alluded to is the result of the fixation due to muscular spasm, forcible passive motion will be of no use, as the reflex spasm will reappear after the effect of the anæsthetic has passed away, as long as the disease of the joint remains.

Local applications to the joint are to be used at the shoulder-joint for the same reasons and indications as in other articulations.

On the whole the results of the conservative treatment of tuberculous shoulder-joint disease are satisfactory except in the case of persons whose general condition is decidedly bad. The great freedom of movement of the scapula allows many arm motions to take place without any movement of the head of the humerus in the glenoid cavity, so that it is easy to secure almost complete rest to the affected joint. In stiffness resulting from chronic rheumatoid arthritis of the shoulder forcible manipulation is harmful and useless during the stages of joint irritation. After the irritation has subsided manipulation, sometimes forcible under an anæsthetic, and sometimes gentle, is of value. Along with the latter should be used massage, electricity, and the douche.

Excision of the Shoulder-Joint.—There is a mortality from the operation of about fifteen to eighteen per cent.

The most favorable age for operation appears to be from ten to twenty; the least favorable being from five to ten years. The disease is rather uncommon in young children, consequently excisions are not frequently performed in childhood. The prognosis after this operation is good, as regards usefulness of the arm; but a stiff joint should be avoided. The movements of the arm are usually impaired in abduction and rotation; due to the injury done the deltoid, and the cutting of the attachments of the rotators of the humerus.

The longitudinal anterior incision is in general the most useful for

[1] Boston Med. and Surg. Jour., August 21st, 1890.

excision of the shoulder. The periosteum is divided with a bone knife, inserted along the inner border of the bicipital groove. The arm is rotated both outward and inward, and the periosteum and muscular attachments are removed as they appear. The head can be removed with the keyhole or the chain saw, removing as much of the bone as is diseased. The operation is performed subperiosteally and the head of the bone may be thrown out of the wound and thus sawed off. In after-treatment, very good fixation can be obtained by bandaging the arm to the side, with a thick pad between the body and the inner side of the arm.

Plaster-of-Paris dressing around the arm and chest affords the best fixation; and after the need of complete fixation is passed, a sling answers every purpose.

Passive motion of the joint should be commenced as soon as possible after the operation, if it is desired to secure a movable joint; but the surgeon in that way runs the risk of making a flail joint, inasmuch as but little of the ligamentous structure has been preserved. Ankylosis of the shoulder is of comparatively slight importance in comparison to obtaining a stable joint on account of the mobility which the shoulder-blade possesses, so that passive motion should not be begun too early and in many cases should not be undertaken at all.

Habitual or recurrent dislocation of the shoulder becomes at times an affection requiring orthopedic treatment.

The name "habitual dislocation" should refer only to those cases in which dislocation occurs from causes too slight to displace the normal joint. A person may dislocate one shoulder two or three times from a succession of severe accidents without falling into this special pathological class.[1] The causes of the condition may be formulated as follows: 1. Laxity of the capsule of the joint. 2. Partial fracture of the head of the humerus. 3. Partial fracture of the glenoid cavity. 4. Tearing away of muscular insertions and rupture of tendons. 5. Abnormality in the shape of the head of the humerus not demonstrably due to fracture, but probably the result of chronic, non-suppurative inflammation.

It would seem as if in certain instances the cause of the recurrence of the dislocation was insufficient immobilization of the arm after a primary dislocation.

The atrophy of certain muscles seems to be characteristic in these cases in a series observed by one of the writers.[2]

Certain of the muscles of the affected side are so notably atrophied and flabby that they at once attract attention on examination. The other muscles are not notably smaller than those of the other side. The

[1] Stimson: "Dislocations," p. 265, quoting also Gurlt, "Path. Anat. der Gelenkkrankheiten," p. 250; Cushing: Med.-Chir. Trans., 1837, p. 336.

[2] Burrell and Lovett: Am. Jour. Med. Sciences, August, 1897.

group of muscles affected are as follows: Coraco-brachialis, triceps, deltoid, especially the posterior part, supra- and infra-spinatus, rhomboids, levator anguli scapulæ, latissimus dorsi.

In a case observed by one of the writers in which three dislocations of the right shoulder had occurred inside of a year, each from a sufficiently heavy fall, there was no marked atrophy of these muscles one week after the third accident.

Limitation of motion is not so much due to pain or to fear of displacement, as apparently to some lesion in the joint mechanism.

It should be noted that a large proportion of epileptics are found in all reported cases. Reduction is, as a rule, easy, and inflammatory reaction in the joint is notably slight or even wholly absent after reduction.

Prognosis.—In a shoulder-joint in which a dislocation has once or twice occurred from insufficient cause it is not likely that the liability will become less frequent as time advances if no treatment is undertaken. As a rule, the dislocations will occur with greater frequency and from slighter causes as time progresses.

Treatment.—The methods of treatment may be classified under four heads:

1. By apparatus. 2. By massage and exercises alone. 3. By temporary fixation and massage. 4. By operation.

1. The use of apparatus confining the arm to the side is to be condemned. It weakens the muscles by causing their disuse. It is uncomfortable and partially disabling, and its use can be considered justifiable only temporarily or under exceptional conditions.

An apparatus used by one of the writers seems as little objectionable as any. It consists of a leather shoulder cap embracing the arm, strengthened by two steel strips, one horizontal strip running from before backward and fitting the outer contour of the shoulder. The other, a longitudinal strip, runs from the base of the neck to the middle of the arm. There is a joint opposite the shoulder, allowing antero-posterior motion in the shoulder. The shoulder cap is fastened in place by a chest band; the apparatus prevents abduction of the arm to any degree likely to produce dislocation.

2. Massage and exercises without apparatus. This treatment is based on the advisability of improving the circulation and nutrition of the shoulder and strengthening the atrophied muscles. The shoulder is allowed perfect freedom during this treatment.

3. Fixation in connection with massage and exercises. Prolonged fixation is called for when a second dislocation has occurred from slight cause. The arm is lifted by applying a sling, which supports the forearm and point of the elbow. The arm is held to the side by a swathe, thus preventing all motions of the joint. This removes as much weight as possible from the joint capsule.

In connection with this treatment daily massage to the shoulder muscles should be employed, and especially to the muscles found atrophied in such cases. After some weeks of fixation motion should be progressively allowed, along with massage and exercises for the muscles ordinarily affected in these cases. This treatment should continue at least three months. Electricity is of help also in causing special contractions of the atrophied muscles. The faradic current of medium strength should be used.

4. *Operation.*—The operative measures advocated have been few.

Malgaigne advocated subcutaneous incision of the capsule of the joint by a tenotome introduced anteriorly, in the hope of producing inflammatory contraction.

Excision of the head of the humerus[1] is a mutilating operation, and will rarely be necessary. It is conceivable that after an exploration of the joint abnormalities might be found which would demand an excision.

Gerster,[2] Ricord,[3] and Burrell[4] have operated successfully on five such cases by reefing the anterior part of the capsule of the joint through an anterior incision.

Obstetrical paralysis of the shoulder will be considered in Chapter XV.

Diseases of the Elbow.

Synovitis may appear in this, as in other joints, from the usual exciting causes, and presents the same characteristics.

Chronic Tuberculous Disease.—The disease may begin with pain, but this is not severe, and often is entirely absent. Limitation of extension of the forearm is a constant and early symptom, motion in this direction being distinctly restricted when flexion, pronation, and supination are free. A slight increase of surface temperature is usually found, but its absence does not exclude the disease. Careful examination will reveal a slight amount of swelling even at this stage of the affection, shown by fulness and thickening on either side of the tendon of the triceps, and, looking at the elbow from behind, the joint appears broader than normal. As in other joints, wasting of muscles occurs rapidly. As the disease progresses the stiffness increases, motion in other directions is restricted and resisted by muscular spasm, and the joint is generally held at an obtuse angle. Starting pains may be added to the other symptoms, and become the source of great discomfort. The whole joint becomes involved in the swelling, the enlargement assuming a fusiform shape.

[1] Cent. f. Chir., 1883, p. 28; Beilage z. Cent. f. Chir., 1882, p. 73, and 1886, p. 90; Deutsch. Zeit. für Chir., 1880, xiii., p. 167; Pitha and Billroth, ii., p. 652.

[2] "Aseptic and Antiseptic Surgery," p. 8.

[3] Bull. de l'Acad. de Méd., 1894, p. 334.

[4] Burrell and Lovett: Am. Jour. Med. Sciences, August, 1897.

The swelling sometimes becomes very great. The skin may become riddled with sinuses, the tuberculous infection attacks the soft parts, and the whole elbow becomes a pulpy, granulating mass. This occurs in neglected cases of elbow disease, and also as the result of relapses after excision of the joint. Tuberculosis of the head of the radius may exist, in which case limitation of rotation and local swelling are predominant symptoms.

The prognosis in tuberculous disease of the elbow is not favorable for re-establishment of motion, unless the affection is treated at a very early stage. The joint is so complicated that the disease involves a large and comparatively widespread surface of synovial membrane before its pres-

FIG. 323.—Tuberculosis of the Elbow. Advanced stage.

ence is discovered. Other forms of joint disease do not present symptoms essentially different from those noted in speaking of other joints.

Stiffness of the elbow is an affection often found disassociated with the signs of active disease. It may result from fracture with the formation of adhesions or the displacement of some of the bony parts of the joint; from synovitis with adhesions of the joint surfaces, and at times even from very slight grades of synovitis; and also it may result from chronic arthritis of a tuberculous or rheumatic type which has caused destruction of the joint and fibrous or bony ankylosis.

Treatment.—The treatment of serious elbow-joint disease is not attended, as a rule, by very satisfactory results. Simple synovitis generally recovers under fixation, which is given either by fixation splints, internal angular, or external angular splints. These can be made of tin or pasteboard, reinforced with iron or wire or wood, and should be fitted to the arm bent to a right angle. Compression can be given by surrounding the joint with cotton and bandaging it with an elastic rubber bandage. In time fixation by splints can be discontinued, and the support of a sling alone relied on, with passive exercises and massage. In small children, pasteboard splints give enough fixation for practical purposes, even in acute cases.

When chronic synovitis or suspected ostitis is to be treated, somewhat more permanent fixation is demanded. This is best furnished by plaster of Paris or moulded leather, which can be worn for some weeks and then be replaced with little disturbance of the joint. The frequent readjustment of splints is objectionable in a sensitive joint. In any event, a sling is to be carefully worn, which shall support the hand and wrist as well as the arm, and whatever apparatus is used it is essential to remember that the elbow should be flexed to a right angle, for if ankylosis occurs in any other position a useful arm is not obtained.

When the joint is fixed by muscular spasm at an angle greater than a right angle, it will often be found possible to rectify this by the application of a fixation bandage to the arm in its malposition. This so quiets the muscular irritation that in two or three weeks it may easily be bent up a little and by the application of a succession of bandages it may often be brought into a right-angled position without the use of the least force.

If the disease progresses, it is of little use to continue conservative treatment; but one must proceed to arthrectomy, or better yet, excision, before amputation becomes the only measure holding out any prospect of relief. Forcible straightening of an ankylosed arm is sometimes useful.

Excision of the elbow is perhaps indicated earlier in the course of the disease than is the case in any other of the larger joints. After infancy is passed, operative interference is indicated whenever it is clear that under expectant treatment the disease is growing worse. Under these conditions, the results are not, as a rule, altogether satisfactory, but if the disease is allowed to go on, the elbow-joint becomes so disorganized that amputation becomes necessary. There are no reliable statistics dealing with the results of the operation, except those of Culbertson, relating chiefly to operations before antiseptic surgery came into use. Of 290 cases which recovered when complete excision of the joint had been performed, 32 were perfect and 196 useful. Ollier, in a series of 50 cases, had no death attributable to operation.

Excision is also indicated for ankylosis in faulty position, as when the elbow is fixed in a position of much more than a right angle or very sharply flexed. The longitudinal incision is the most serviceable. The forearm is slightly flexed, and the incision, about three and one-half inches long, is made a little to the inner side of the median line over the triceps and ulna and is carried down to the bone throughout its entire length. The inner edge of the divided periosteum is raised from the ulna with the corresponding half of the tendon of the triceps, and the dissection is continued with the knife close to the bone, toward the internal condyle. Much care must be taken to preserve the connection between the periosteum, the muscular attachments, and the internal lateral ligaments. A similar dissection should then be made upon the outer side with the same precautions. The humerus is dislocated backward through

the wound and sawed off wherever it may be necessary. In other cases it may be advisable to use the keyhole or chain saw, and so far as may be necessary, the ulna is cleared and sawed through, the head of the radius being removed with the saw or bone forceps.

In certain cases, in which sinuses exist, it may be better to adopt some informal method of operation which will be suggested by the direction and location of the sinuses, or abscesses.

The after-treatment is similar to that of other excisions: complete rest to the joint and fixation in a right-angled position. This at first can be best obtained by the use of a plaster-of-Paris splint applied outside of a large antiseptic dressing. Later, in the course of the convalescence, bracketed tin or wooden splints may be of use; or, if one desires, the original plaster-of-Paris splint may be bracketed with strips of iron.

In excision for elbow disease, as a rule, ankylosis is aimed at as the best possible result, so that passive motion is not to be considered; if, however, the operation is performed in adults for ankylosis or injury and the ligaments have been in a measure fairly preserved during the operation, it may be advisable to begin passive motion after a moderate degree of firmness in the tissues has been reached, as there is but little danger of a flail joint, and it is reasonable to expect that a certain degree of motion at the joint may thus be obtained.

Arthrectomy.—In place of a formal excision, the elbow can be incised, and all attainable tuberculous tissue dissected out and the bone curetted. This is a procedure especially useful in children, but the complicated nature of the articulation makes it difficult to remove at all thoroughly the diseased synovial membrane. The operation of arthrectomy was considered in detail in speaking of tumor albus.

Diseases of the Wrist.

Synovitis may occur under the same conditions existing in other joints. *Teno-synovitis* is characterized by pain on the motion of certain fingers, with, perhaps, a sensation of rubbing or creaking in the affected tendons. Tender points are present in the course of these tendons. In the superficial tendons of the wrist, some distention of the synovial tendinous sheath can be seen.

Chronic Arthritis Deformans.—The wrist is a common seat of this affection, with the ordinary symptoms of pain, swelling, stiffness, creaking, etc. When deformity has occurred, the wrist is generally flexed, and the distal ends of the radius and ulna are enlarged and project backward. Frequently the hand is adducted, this often being associated with a similar distortion of the fingers.

Arthritis deformans and other forms of synovitis of the wrist should be treated on the principles already indicated for these affections.

Tuberculous disease is characterized by swelling, heat, and stiffness. If the disease is advanced, deformity and swelling will be added to the other signs. The hand may be held flexed on the forearm at an angle of 120° to 130°, and this position is fairly constant. Swelling appears first in the depressions between the tendons. Later, measurement will show the joint to have increased in circumference, and there is a fulness of outline, especially on the dorsal surface, and in destructive disease the swelling extends up on the forearm and down on the hand. Suppuration is very liable to occur, and the course of the disease is usually long and slow.

In the matter of diagnosis, it may be added that swelling is always present, and that with the wasting of the muscles, the heat, and the limitation of motion, it makes up the clinical picture of the disease.

In tuberculous disease of the wrist-joint, fixation is indicated, and it is most easily obtained by the application of anterior and posterior common wooden splints and carrying the arm in a sling. Plaster of Paris forms a more permanent dressing, and is equally comfortable.

Treatment.—The conservative treatment of disease of the wrist must not be dismissed without a mention of the great benefit often to be derived from compression and fixation together. This is obtained in the Gamgee dressing. Not only in ostitis, but in teno-synovitis and simple sprained wrist, this method is of very great value. As a rule, the active symptoms subside when rest is furnished to the diseased joint; but the cure of the disease is another matter and requires a long time. The great extent and free communication of the synovial sacs of the wrist make the disease an extensive one when located there.

Excision of the joint is indicated in the severest cases, or in those which progress badly under conservative treatment. In a series of 79 cases of excision of the wrist, the results in 24 per cent were worthless, 46 per cent secured useful limbs, and in 8 per cent perfect results followed the operation. In this series of cases both partial and complete excisions are included. Gross gives in his tables a mortality of about 11.7 per cent for excisions and 12.8 per cent for amputations of the forearm. Ollier reports seventeen resections of the wrist-joint in which the results were excellent; subsequent amputation was needed in none, and all recovered with useful hands, being able either to write or to carry out light work, and, in some cases, to lift weights. Motion at the finger-joints and at the wrist became quite free. The best result is either ankylosis or limited motion, and, therefore, as much bone as possible should be saved. Other things being equal, a loose joint entails less power in the hands and fingers.

According to Culbertson's tables,[1] however, the results in resection at

[1] Transactions American Medical Association, 1876, supplement to vol. xxvii.; Boston Medical and Surgical Journal, October 26th, 1882, p. 388.

the wrist-joint would appear to be rather more favorable than indicated by Bidder.[1] In the table of excisions of the wrist for disease, 7.59 per cent secured "perfect" results, 45.57 per cent "useful" limbs, 24.03 per cent "worthless" limbs. The average period of recovery in thirty-five cases was nearly two and a half years.

The method of Lister is performed by a radial and dorsal incision. The radial incision commences at the middle of the dorsal aspect of the radius at the level of the styloid processes. It is directed toward the inner side of the metacarpo-phalangeal articulation of the thumb, and on reaching the radial border of the second metacarpal bone it is carried downward longitudinally for half the length of the bone. The soft parts are detached from the bones with the periosteal elevator or the blade of the knife, and the radial artery is thrust somewhat outward. The soft parts on the ulnar side are dissected up as far as is practicable, while the extensor tendons are relaxed by bending back the hand. The knife is then entered on the inner side of the arm for the ulnar incision two inches above the end of the ulna, and is carried downward in a straight line as far as the middle of the fifth metacarpal bone at its palmar aspect. The tendon of the extensor carpi ulnaris is cut at its insertion into the fifth metacarpal and dissected up from its groove in the ulna, while the tendons of the extensors of the fingers with the radius are left undisturbed. The anterior surface of the ulna is cleared by cutting close to the bone. The anterior ligament of the wrist-joint is divided and the junction between the carpus and the metacarpus is cut, the former being extracted through the ulnar incision by bone forceps and the use of the knife.

If the hand is deverted, the articular heads of the radius and ulna will protrude at the ulnar incision, and as much as may be necessary is then removed. The metacarpal bones are also protruded and dealt with in the same way. The articular surface of the pisiform bone is cut off and the trapezium is dissected out. The operation may, however, be performed by a long, single dorsal incision, a method identified with the name of Langenbeck, which should begin at the centre of the ulnar border of the metacarpal bone and the index finger, and be carried upward to the middle of the dorsal surface of the epiphysis of the radius, and dissected down to the bone. The sheaths of the tendons are lifted with the periosteum and carried to the radial side of the long incision; the hand is flexed and the articular surface of the upper row of carpal bones is exposed. The ends of the radius and ulna may be denuded and thrust through the wound and sawed off in the usual way. Here, as in other excisions, informal methods of operating may be necessary on account of the situation of abscesses and sinuses.

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[1] Archiv f. klin. Chir., 1883, 28 Bd., iv., p. 822.

The operation is indicated when expectant treatment has failed, but the joint is so easily fixed and so accessible that mechanical treatment works at good advantage. Operation is attended with so much deformity of the wrist and such doubtful results on account of the very extensive surface of the serous membrane that excision should not be lightly undertaken. The after-treatment is simple, because the hand can be kept so easily at rest upon a palmar splint; but any form of splint may be applied which will afford permanent and efficient fixation. In children excision should be done only in severe cases, when conservative treatment has failed. As in ankle-joint excision the whole of every diseased carpal bone should be removed.

Sacro-Iliac Disease.

This affection is also known as sacro-coxitis (Hueter), sacrarthrocace, and sacro-coxalgie. By sacro-iliac disease is meant disease of the sacro-iliac synchondrosis.

Disease of this joint is a rare condition. It is essentially a disease of young adult life, being slightly more common in men than in women. Delens cites 20 cases in which the age ranged from 18 to 45 years, and the youngest case which came under Erichsen's observation was a patient 14 years old. Van Hook, in 32 cases in which the age was recorded, found that less than 22 per cent were below 15 years of age.[1] Poore, however, reports cases which he has seen in young children. The acute form of the disease, which is extremely rare and quite violent, runs its course rapidly, attended by high fever and suppuration, and is apt to terminate fatally from exhaustion. The chronic form practically means tuberculous disease, although some writers would classify these cases under three heads: tuberculous, puerperal (pyæmic), and gonorrhœal, with a fourth class possible, *i.e.*, syphilitic.[2]

Pathology.—The pathological lesions which are found in these cases are not unlike those accompanying chronic inflammation in other joints.

Etiology.—The etiology is also, in large part, similar to that of chronic disease of this type in other joints; traumatism and the strain of parturition being assigned as the commonest causes. Chauvel[2] asserts that the affection is fairly common in young cavalry soldiers, and assigns as the exciting cause the traumatism from the equestrian exercise, this joint being called upon to support the weight of the trunk.

Symptoms.—In the early part of the disease, such symptoms as a slight abdominal distress, difficulty in micturition or in evacuation of the bowels, easy fatigue, a feeling of indisposition, etc., are often present, and as the disease progresses more pronounced signs appear. Pain is

[1] Van Hook: Ann. of Surgery, 1888-89.

[2] "Ref. Handbook of the Med. Sciences," vol. vi., p. 240.

nearly always present, and may vary much in intensity. It is made worse by standing, and is almost always relieved by lying down. It is also apt to be more severe at night, and is increased by pressure upon the trochanters or wings of the ilia. The pain varies in situation, and may be referred to the course of the sciatic nerve. Sensitiveness upon pressure over the joint is a common symptom, and this may be developed over the anterior part of the joint by palpation through the rectum. Some swelling, or a boggy feeling, is usually present about the articulation, and if it goes on to abscess formation the fluctuating swelling may present at almost any point, either directly backward into the lumbar region, or it may become intrapelvic, in which case it may appear in the groin as a psoas abscess, or point in the ischio-rectal fossa, or at either of the sacro-sciatic notches. Limping is practically always present.

The position of the body in walking or standing is fairly characteristic, the weight of the trunk being thrown upon the well foot, while the other leg hangs down; this exerts a slight extension by its weight. In walking the gait is very cautious, all jar is avoided, and hence the toe is largely used instead of the flat of the foot on the diseased side. Atrophy of the muscles of the leg upon the affected side is usually present, and is seen, as in other chronic joint affections, quite early in the disease.

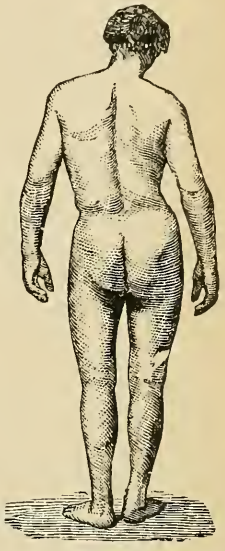

FIG. 324.—Attitude in Sacro-iliac Disease.

Diagnosis.—Sacro-iliac disease has been mistaken for sciatica, but aside from the fact that the latter is usually found later in life, the pains are not relieved by the recumbent position.

In lumbago the pain is more diffuse and higher up than in disease of the sacro-iliac articulation.

Inflammation of the psoas muscle (psoitis) more usually simulates hip disease, but it may be mistaken for sacro-iliac disease. In this there is no tenderness over the joint, and the pain which is present is increased by extension of the thigh, while flexion relieves it.

Positive diagnosis of sacro-iliac disease from hip disease and Pott's disease in the lumbo-sacral region is at times difficult and often impossible, especially in the class of cases just referred to. In hip disease all manipulation is resisted by muscular spasm, while in sacro-iliac disease, with the iliac bones held firmly, all motions at the hip are possible without pain. Also in hip disease the pain is never increased by pressure upon the wings of the ilia as is the case in sacro-iliac inflammation. In spinal caries we have a prominence of some of the spinous processes with

rigidity of the spine when motion is attempted, and local tenderness is not present over the sacro-iliac articulation, nor does pressing together the ilia cause pain.

Prognosis.—The prognosis in this disease is at best quite grave. Cases do recover, but it is one of the most chronic of joint affections, and usually goes on to abscess formation, with prolonged suppuration and death either from exhaustion, renal complications, or secondary tuberculosis.

Van Hook [1] reported thirty-eight cases with abscess, of which only three recovered.

Treatment.—The principles of treatment are the same as in all chronic joint affections. In the acute stage the patient should be kept upon the back in bed, with weight-and-pulley extension to the leg, and as the acute symptoms abate he may be allowed to go about on crutches, with a high sole upon the well foot, the weight of the other leg serving as extension. While moving about, a certain amount of comfort may be derived from a swathe, either of cotton or of adhesive plaster, about the pelvis, which serves in part to fix the joint.

When an abscess has formed, it should at once be laid open, any diseased bone removed, and treated like any cold abscess. When the abscess is intrapelvic it may be quite difficult to reach, and Van Hook describes a very ingenious method for reaching and draining the cavity. An incision is made near the posterior part of the crest of the ilium on the affected side, the tissues are divided down to the bone, and a piece of the ilium is chiselled away. This brings the joint within reach, and through the opening any diseased bone may be removed and the cavity drained. Excision of the sacro-iliac synchondrosis may be done in severe cases. Such cases have been reported by Buchanan.[2]

In all of these cases tonics and constitutional treatment are not to be neglected.

Phalangeal Articulations.—Owing to their position exposed to sprains, blows, etc., the phalangeal joints are frequently found enlarged, slightly deformed, and stiff.

The hand is a very common seat of arthritis deformans, which often begins in one or two joints of one finger, and some time elapses before it attacks the others. The joints become much enlarged, and distortion usually occurs to the ulnar side, this adduction being chiefly in the metacarpo-phalangeal joint. The fingers may become permanently distorted, flexed or abducted, or both; the second phalanges of the fingers, as well as of the thumb, are usually extended, giving a characteristic appearance to the hand.

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[1] Journal of the American Medical Association.

[2] Memphis Lancet, December, 1898.

Temporo-Maxillary Articulation.—By far the most common affection of this joint occurs in chronic rheumatoid arthritis, which presents the same characteristics as when occurring elsewhere and which may result in ankylosis.

Tuberculous disease may occur, secondary to disease of the ramus or ear, but it is rare.

Subluxations occur from relaxation of the ligaments, usually in young people, and most frequently women. The patient suddenly finds himself unable to close the mouth, and until he has acquired the method of reducing the dislocation himself, it must be accomplished in the routine way as in the treatment of traumatic dislocation. A tendency to this accident, once established, is usually permanent.

A blister applied over the articulation sometimes appears to have a beneficial effect, but generally the affection becomes better or worse independent of any treatment, local or general, at times causing a great amount of discomfort and at other times not being noticeable.

Sterno-Clavicular and Acromio-Clavicular Joints. — Enlargement of these joints sometimes occurs in persons accustomed to hard work with their upper extremities. Inflammation of the sterno-clavicular articulation, followed by suppuration, is occasionally observed, but presents no unusual symptoms. Chronic rheumatoid arthritis may occur in either of these joints, causing pain and stiffness, enlargement, and weakness of the upper extremity.

Articulation of the First and Second Pieces of the Sternum.—Disease in this situation is rare, but has been described by Hilton. The symptoms were pain about the sternum, especially severe on forced or sudden respiratory exertion, and great tenderness over the joint. Recovery took place. Fixation and expectancy are all that can be done for these joints.

Symphysis Pubis.—Cases are recorded of chronic disease of this joint,[1] as well as of its complete ossification in comparatively young people.[2]

Sacro-Coccygeal Disease.—Disease of the coccygeal joint is rare, yet several well-marked cases have been recorded. The condition may be detected by means of the thickening over the joint and pain upon motion. By the rectum, distinct grating of the diseased surfaces may be felt when the joint is moved. When the joint is clearly involved, excision of the coccyx is the best treatment. Ankylosis is not a rare occurrence, and the union may take place with the bones in almost any position.

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[1] Holmes' "System of Surgery," vol. iv., p. 88; Bryant: "Practice of Surgery," p. 919.

[2] Otto, quoted by Holmes.

CHAPTER XI.

CLUB-FOOT.

Frequency.—Anatomy.— Causation.— Symptoms.— Diagnosis.— Prognosis.—Treatment.—Club-hand.

The term club-foot is popularly applied to a deformity characterized by an inversion, torsion, and depression of the front part of the foot with an elevation of the heel.

In walking on a foot thus deformed, the weight of the body is borne, not by the sole of the foot, but by the outer side, and in extreme cases by the dorsum of the foot.

The distortion is also known as talipes equino-varus.

Other names in use are: "Reel" foot—Pes contortus.

German: Klump-Fuss.

French: Pied bot.

The deformity is either congenital or acquired.

Frequency.—Club-foot is by no means an uncommon distortion, and was mentioned in literature even in the days of Homer.[1] Tamplin, among 10,217 cases of deformity treated at the Royal Orthopedic Hospital, met with 6,754 club-feet, of which 1,780 were congenital. Chaussieur, among 22,923 newly born infants, reports 37 cases of club-foot. Lannelongue, among 15,229 births at the Paris Maternity Hospital, found 8; and Duval, in 1,000 cases of club-feet, found 574 congenital, of which 364 were males and 210 were females.

Anatomy.

The deformity is a dislocation inward of the anterior part of the foot, the dislocation taking place at the medio-tarsal articulation. All the tissues are necessarily affected by the abnormal position, and the skin, muscles, tendons, and fasciæ are all altered.

In all cases of congenital club-foot, even in that of a full-term fœtus, the scaphoid bone will be found articulating with the side of the head of the astragalus rather than with the anterior surface. The articulation is also more toward the under side of the astragalus, the head of which is thus uncovered.

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[1] "Iliad," i., 599; xxi., 331.

The scaphoid may be so far distorted to the side as to articulate at one end with the tip of the internal malleolus. In one instance in the ankle of a full-term fœtus, dissected by the writers, a separate synovial sac was found between the end of the astragalus and the malleolus. In infantile cases the distortions in the shape of the bones are of little importance, as the ends of the bones are largely cartilaginous. The position of the tarsal bones is, however, not the normal one. The cuneiform bones being intimately connected with the scaphoid follow the displacement of the latter, and the same is true of the metatarsal bones and the phalanges, so that the long axis of the front of the foot forms a right angle, or even an acute angle, with the axis of the leg. The cuboid is necessarily displaced to the inner side and does not articulate with the front of the os calcis, the facet of which also inclines obliquely to the inner side.

FIG. 325.—Dissection of Normal Foot. (Burrell.)

In fully developed cases, and in older children or adults, there is a marked alteration in the shape of the bones. The alterations of the bones which have been noticed are chiefly in the position and shape of the following bones: viz., the os calcis, cuboid, astragalus, and scaphoid.

The os calcis, by the elevation of the tuberosity, is drawn from a horizontal into a position approaching the vertical. It is also more or less rotated on its vertical axis, so that its anterior extremity is directed outward and the posterior extremity inward, and thus the anterior articulating facet is oblique to the axis of the bone. The cuboid bone maintains its connection with the os calcis, but follows the inward direction of the anterior extremity of the foot.

There is no rotation of the astragalus on the vertical axis, but, as has been stated, it is depressed forward on its horizontal axis, so that only the posterior portion of its superior articular surface is in contact with the inferior articular surface of the tibia, and the anterior part of its anterior facet projects beneath the skin of the dorsum of the foot.

Besides this displacement, the shape of the bone is altered by the twisting inward of the head and neck, so that the anterior articular surface looks inward instead of forward, and the disposition of the cartilage at the articulating surfaces of the head of the astragalus is necessarily altered. The three cuneiform and the three metatarsal bones being closely connected with the scaphoid are more twisted to the inside than is the case with the cuboid, though the metatarsals are not all equally involved in the rotation from without inward and are spread out something as the branches of a fan, in such a way that the anterior part of the foot is enlarged more than normal. Besides these alterations in the position of the foot others take place secondarily, depending on pressure and the effect of locomotion on the distorted bones.

FIG. 326.—Dissection of Club-foot. (Burrell.)

The different tendons assume an abnormal direction and in general are carried farther to the inside than is normal; this is especially true of the tibialis anticus, the common extensor of the toes, and the long extensor of the great toe. Synovial bursæ may form on the outer edge and back of the foot, which may become inflamed and suppurate; corns and callosities are also formed on the skin, from the pressure of walking. No change has been found in the nerves or the spinal cord in cases of club-foot.

In extreme cases there may be slight alteration in the shape of the femur, and a laxity at the knee-joint; the tibia has also been found altered, and the same is true of the fasciæ. The muscles are never found paralyzed in congenital club-foot, but the contracted muscles seem more developed than the lengthened muscles. The muscles of the leg atrophy from disuse, and the leg is much smaller and the foot shorter than normal.

In addition to the faulty shape of the bones there is a change in the ligaments and fasciæ, and this is not confined to the severe and most inveterate cases, but is always present. Not only are the plantar ligaments and fasciæ contracted, but the internal lateral and posterior ligaments are also contracted.

Causation.

The deformity is usually a congenital one, but it may also be acquired, after the impairment of muscular power which takes place in paralysis,

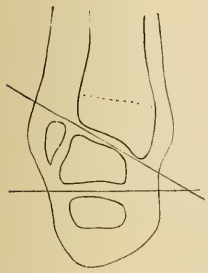

Fig. 327.—Section of Foot and Leg in Club-foot.

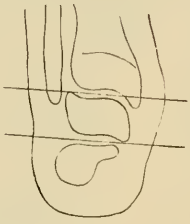

Fig. 328.—Section of Foot and Leg. Normal.

Fig. 329.—Relation of Astragalus to Os Calcis. (Whitman.)

and after accident. In regard to the etiology of congenital club-foot, various theories have been advanced in explanation of the deformity.

A popular idea is that the distortion is due to maternal impressions, but no conclusive evidence in regard to this has been obtained. Dabney[1]

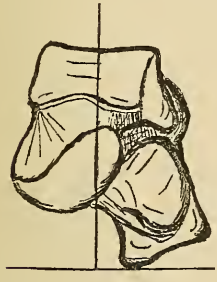

Fig. 330.—Relation of Astragalus to Os Calcis in Flat-foot. (Whitman.)

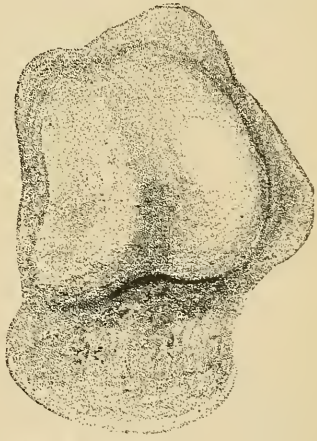

Fig. 331.—Normal Adult Astragalus.

collected ninety cases of maternal impressions apparently causing deformity. In none of these was club-foot produced.

Heredity, on the part of both the father and mother, has been established without doubt in a certain number of cases, but in a very large majority no trace of similar deformity in ancestors can be found. Devay

[1] Dabney: "Cyclopedia of Diseases of Children," vol. i.

and Boudin report that more cases of club-foot are found in children from marriages of kin than among others. One case in 164 births from marriages of kin, and 1 case in 1,903 of other marriages are reported.

FIG. 332.—Astragalus from an Adult Club-foot.

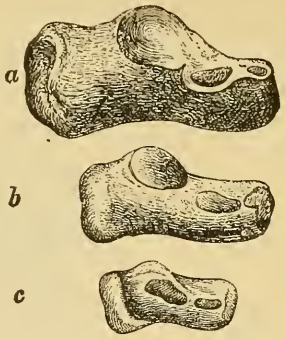

FIG. 333.—The Os Calcis in, *a*, child of one year with club-foot; *b*, normal new-born; *c*, new-born infant with club-foot.

FIG. 334.—Obliquity of Neck of Astragalus.

The chief theories which are advocated to explain the deformity in uterine life are as follows:

First.—Abnormal compression in the uterine cavity.

Second.—Retraction or paralysis of muscles depending or not on lesion of the nervous system occurring in utero.

Third.—A malformation depending upon arrest of development of the foot.

The first of these explanations is as old as Hippocrates. Ambrose Paré and Cruveilhier maintained the same idea, except that the latter

FIG. 335.—Side View of Astragalus Normal and in Club-foot.

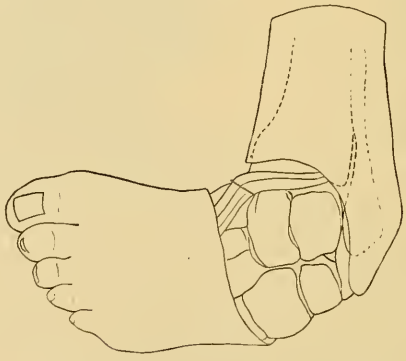

FIG. 336.—From Specimen of Adult Club-foot.

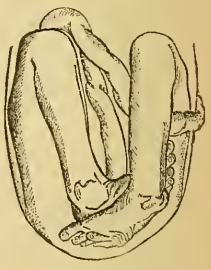

FIG. 337.—Compression of Fœtus in Utero. (Parker.)

believed that a blow received by the mother was an influential cause, and states that when club-foot is single, the anterior foot in utero is the one affected, and when the deformity is double, the anterior foot in the

uterus is affected to a greater degree. Malgaigne also maintained the same opinion.

The theory of abnormal difference in the strength of the leg muscles dependent or not on disturbances of the central nervous system has been

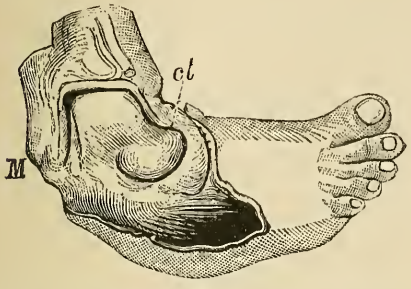

FIG. 338. — *M*, Malleolus; *ct*, astragalo-scaphoid articulation. (Schreiber.)

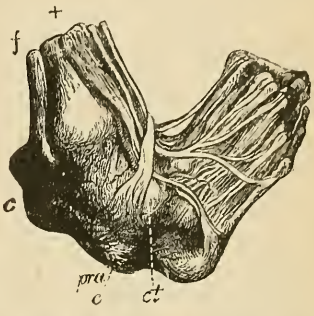

FIG. 339. — Pes Varus in an Adult. (Schreiber.)

held by many writers. Morgagni, Benjamin Bell, and Delpech believed that the contraction of certain muscles caused the deformity, while Beclard believed the weakness of other muscles was the influential factor. Confirmatory of this view is the fact that the deformity is often seen in hydrocephalic and anencephalic fœtuses, and those suffering from spina bifida. But this idea is not supported by the fact that in a large majority of cases no alteration of the nervous system can be found. Out of

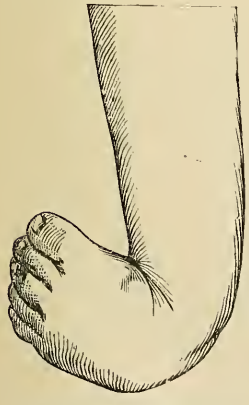

FIG. 340.—Congenital Talipes Equino-varus.

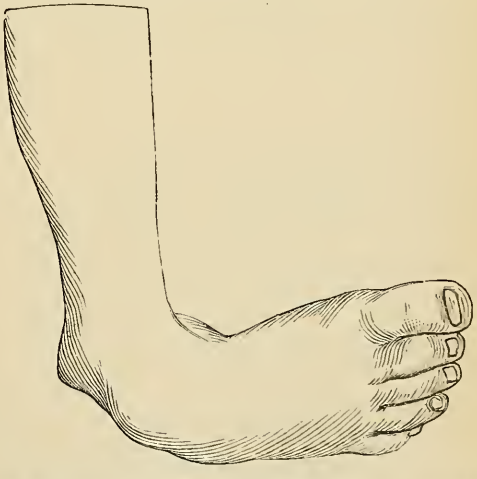

FIG. 341.—Adult Club-foot with Outer Edge of the Foot Resting on the Ground in Walking.

688 cases of congenital varus in the London hospitals, only 2 were affected with spina bifida. Duval, out of 574 cases of club-foot, found no other deformity present; Lannelongue found in 78 cases of monstrosities

27 which were free from club-foot, and in 32 cases of spina bifida and encephalocele only 4 club-feet were seen.

The third theory, that of arrest of development of the foot, is the one maintained by Meckel, Saint Hilaire, Adams, Hueter, and others. According to these authors, since the feet are developed normally at the sixth or seventh week, the fœtus has the sole turned inward, and a permanence of this position would give rise to a club-foot.

FIG. 342.—Congenital Equino-varus, Showing Position of Head of Astragalus.

Cruveilhier has denied this anatomical fact, but it is maintained by Martin and others; and although this theory explains the deformity of varus, it is incapable of explaining that of other varieties of congenital talipes. This theory has been modified so as to admit, not only the arrest of development properly so called, but the malformation of the bone which forms the skeleton; an opinion defended by Bouvier, Brocher, Lannelongue, and others.

The subject of the causation of club-foot has been carefully investigated by Parker and Shattuck,[1] Berg,[2] and Scudder,[3] but the subject is still unsettled, though their investigations seem to point to retarded rotation as the immediate cause of the deformity.

Parker and Shattuck have called attention to the fact that in anthropoid apes there is an inward obliquity of the neck of the astragalus, and

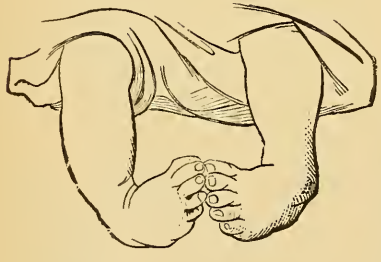

FIG. 343.—Infantile Equino-varus.

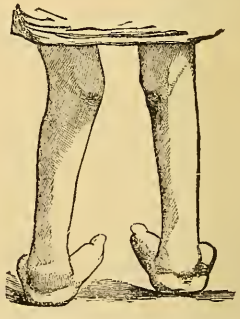

FIG. 344.—Severest Form of Club-foot.

yet no club-foot exists in these animals. To confirm this fact, Dr. E. G. Brackett examined the skeletons of several monkeys at the Boston

[1] Brit. Med. Jour., 1886, vol. ii., 10.

[2] Archives of Medicine, N. Y., December 1st, 1882.

[3] "Boylston Prize Essay," 1887, Boston Med. and Surg. Journal, October 27th, 1887.

Natural History Museum, and found that, in two skeletons of monkeys examined, the angle of inclination of the neck of the astragalus was not over 20°, and in two others, 30° and 35°. The articular surface faced, however, in each case, nearly directly forward, being set on the neck at an angle. The effect of the inclination of the neck was to broaden the tarsus at this point, rather than to give any effect of talipes. Although the anthropoid apes are not club-footed, they are quadrumana, the toe being prehensile and placed obliquely inward, instead of being parallel to the axis of the foot. One feature of a varus distortion is present, and probably explains the alteration in the neck of the astragalus.[1] The conclusion to be derived from all this is, that it may be said that we are entirely ignorant of the causation of club-foot, and unable to give a reasonably satisfactory explanation of the phenomena of its development.

FIG. 345. — Infantile Talipes Equino-varus.

FIG. 346.—Resistant Club-foot.

SYMPTOMS.

Club-foot gives rise to great inconvenience in walking. In uncorrected cases, however, the amount of skill and agility patients acquire in locomotion is surprising, even though the deformity remains unchanged. Bursæ and callosities form over the unprotected portions of the foot, and may inflame and cause much discomfort, limiting the amount of the patient's activity. A laxity of the knee-joint is sometimes developed in consequence of club-foot, and some change in the shape of the femur and tibia and fibula occurs. No alterations of importance of the pelvis take place, though there is undoubtedly a distortion of the head and neck of the femur which causes an increased awkwardness in gait.

Although club-foot is not an affection which interferes with activity or usefulness, the deformity is so marked that it is a source of great mental suffering. Lord Byron presents a notable instance, and Talleyrand is said to have entered the church on account of this distortion.

[1] R. W. Parker and Shattuck: Brit. Med. Jour., May 24th, 1884, p. 998.

Dieffenbach states that of all the women treated by him only one was married, indicating that the deformity was a great impediment to marriage.

The gait of these patients is characteristic. In double cases the feet are lifted one over the other as a step is taken, giving a peculiar appearance, and perhaps suggesting the popular name of "reel" feet.

The distortion presents an inward twist of the foot, with a depressed position of the outer edge. The tendo Achillis is firm and hard to the touch; the plantar fascia will be found short and hard on palpation. The front of the foot projects to the inside of the vertical axis of the leg, the tendinous end of the os calcis is raised and turned inward, the leg is turned outward, and the head of the astragalus and cuboid project under the skin. There is usually atrophy of the muscles of the leg. The external malleolus is prominent and the internal malleolus not readily felt.

Diagnosis.

There is no difficulty in recognizing the deformity of club-foot. In infancy, a true club-foot is sometimes thought to exist when the trouble is simply a temporary spasm of the tibialis muscles which turn the foot in. This passes away in a short time and should occasion no anxiety.

The deformity may, for practical purposes, be divided into three classes.

First.—When the foot can be brought nearly into a normal position by manipulation with the hand.

Second.—When the axis of the foot can be brought into the line of the axis of the leg, but the foot cannot be brought to a right angle.

Third.—When little alteration can be made by manual manipulation of the foot.

The history of the case establishes a diagnosis between the congenital and non-congenital forms of club-foot. The paralytic form can be recognized by the evidence of paralysis of the muscles on the anterior and external surface of the leg. Paralysis, it may be added, is the only common cause of acquired club-foot. The severity of cases of club-foot cannot be determined always by the apparent distortion. Cases resembling each other in outward appearance may prove less or more difficult of treatment. As a rule, however, it may be said that the younger the patient the less resistant the deformity, and it is often convenient to consider the cases as

1st. Infantile—*i.e.*, infants in arms.

2d. Walking cases—*i.e.*, cases in young children in which the feet have been walked upon before the deformity has been corrected.

3d. Resistant cases—*i.e.*, those which have resisted treatment, or in which treatment has been inefficient.

4th. Neglected cases, those so neglected that but little successful treatment has been attempted until the feet have grown for years in a severely distorted position.

Prognosis.

In regard to the prognosis of the deformity, it may be said that the distortion does not correct itself, and if left uncorrected, remains the most obstinate of malformations.

The deformity is one which is essentially curable; in fact, it may be said that it is always curable, provided care and attention can be given by both surgeon and nurse.

The amount of time needed for treatment varies according to the method employed. Formerly much time was needed in the treatment of inveterate cases, but since the introduction of open incision and tarsal resection, when necessary, correction can be accomplished in a short time.

In infantile cases the time required for correction is relatively short, but retentive appliances are needed for a longer time. In fact, it may be said in general, the older the cases and the larger the foot the more difficult the correction, but the less the danger of relapse after correction.

In regard to the permanence of the cure and the danger of relapse, it may be said that if perfect correction is attained relapse is exceptional, if moderate care is used in the employment for a time of retentive appliance.[1]

But it must be borne in mind, especially in the case of young children, not only that the correction must be complete, but efficient appliances for keeping the proper position of the foot in walking (retentive or walking appliances to be described) must be worn until the gait and attitude are perfect. In club-foot half-cures are practically no cures.

Treatment.

Treatment of club-foot necessarily varies, in a measure, according to the patient's age and the duration and nature of the deformity; but it may be said in general that the treatment should be purely mechanical, or both operative and mechanical.

The object of treatment is the correction of the distortion and the retention of the foot in a corrected position until any return of the deformity is impossible.

The treatment of club-foot, therefore, requires.

1. A rectification of the misplaced bones and a lengthening of shortened and contracted tissues.

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[1] Trans. Am. Orthop. Assn., vol. i., Club-foot.

2. A retention in a normal position until the abnormal facet of the astragalus and the other tissues become, under the pressure of new position, normal.

The first of these can be done by mechanical means, stretching or tearing the ligaments and tendons (forcing the foot into shape), or with the help of tenotomy or incision. It may be done gradually or quickly.

The second is purely a mechanical problem, and the retentive appliance should be worn for a longer or shorter time, according to the size of the distorted bone and the amount of the distortion.

The rational treatment of club-foot is of comparatively recent date.

Hippocrates recommended the use of bandages and appliances of copper, lead, or leather secured to the skin by means of resin. A cord sewn to the bandage and wound around the foot at the side of the small toe pulled the foot outward when tightened. This appliance, it will be seen, resembles the one recommended by Barwell. Cheselden recommended a starch bandage, in which the modern plaster bandage finds its prototype. But although some attempt shave always, in all probability, been made to correct club-foot, there is no reason to think that in earlier times any success followed these attempts. The custom of distorting the feet of Chinese ladies is, according to tradition, a relic of an edict to render the deformity of an imperial child less noticeable by making the malformation common—a confession of the impossibility of cure.[1]

Even in later times, up to the beginning of this century, the treatment of club-foot had fallen into such discredit that success was not regarded as possible. Lord Byron, as is well known, abandoned any attempt at correcting the deformity after being treated for several months by Sheldrake.

At that time the treatment was purely mechanical, but the introduction of tenotomy brought such apparently brilliant results that this procedure was regarded as of itself a cure. So much did this theory prevail that mechanical treatment came to be regarded as of secondary importance—a view not held or advocated by surgical authorities on the subject, but adopted so frequently in practice that many unsuccessful or partially successful cases were to be met. Recently, since the perfection of the details of antiseptic and aseptic surgery, more radical measures have been advocated, such as open incision, osteotomy, and excision of the bones of the tarsus in the treatment of the most inveterate cases.

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[1] This explanation of the Chinese custom is not, however, universally accepted, and the origin is certainly obscure. The custom was present as early as the sixth century A.D. and the deformity is referred to by the poets as indicating beauty. This idea became so widespread that although in 1664 A.D. an edict was published prohibiting the practice of distorting the feet, owing to public opinion the edict was withdrawn.—Pall Mall Gaz., 1889, p. 1074.

In addition to this, and in a measure counter to this tendency, the perfection of mechanical appliances and of correcting methods in the last decade have made the treatment of many forms of club-foot possible without such radical measures, or even in many instances without tenotomy.

It is hardly necessary to consider the early methods of correction of club-foot, which, previous to the time of Stromeyer, were entirely mechanical. Cures seem hardly to have been attained, although some successful cases are reported. In all probability the correction was incomplete, and the results to-day would not be considered perfect cures.

At the present time, few procedures in surgery are as precise in their indications and as certain in their results as the methods for the correcting of club-foot.

The correction of club-foot should be divided into two steps, whether the treatment is mechanical or operative.

1st. Correction of the varus deformity.

2d. Correction of the equinus deformity.

In other words, the front of the foot should be twisted out and afterward be raised. This will be found of practical importance, as the foot is more easily twisted before than after the equinus deformity is overcome. In addition to this, as there is invariably some alteration in the facet of the astragalus, some mechanical form of retention of the corrected foot is necessary, until the bone adapts itself or is shaped to the normal position and until the muscles of the foot and leg, altered by the distortion, recover their normal tonicity. In short, treatment involves methods of correction and of retention of the corrected position.

The methods of correction are either mechanical, or a combination of both *mechanical* and *operative* means.

The operative procedures which are to be considered in treating club-foot are:

Tenotomy.

Division of the ligaments.

Incision.

Forcible correction and excision.

Mechanical Correction.—The simplest method of correction is by the use of the hands, and in the case of a new-born infant with club-feet the mother may be directed to manipulate the foot, and having rectified the deformity by gentle force several times daily, to hold it as straight as possible for a minute or two each time. The writers can record as a clinical curiosity the result of a case of congenital deformity of one foot, in a child under a year old, in which the treatment was thoroughly and continuously carried out by a nurse and mother alternately for three months. At the age of five the child presented an equino-varus foot of moderate type as to deformity, but severe as to resistance. In walking the weight

fell chiefly on the outer side of the sole; the foot could be nearly brought into a normal position by the use of moderate force, but the deformity could not be over-corrected, and under free manipulation possible from anæsthesia well-marked distortion of the neck and articular facet of the astragalus was found; but the patient presented but little noticeable distortion of the bared and none of the clothed foot. Tenotomy of the tendo Achillis was performed and the patient's walking was improved.

Another ready method in correcting club-foot is by repeated fixation in a plaster-of-Paris bandage, the foot being held as nearly in a corrected position as possible at each application of the bandage until the bandage hardens. The bandage should reach above the knee, where the limb should be slightly bent to prevent the plaster bandage (which should be renewed every two or three weeks) from rolling around the limb, and to prevent the child from kicking it off. This method is chiefly applicable to young children or infants and can be made efficacious.

In the case of small children with plump legs, and in resistant cases, it will, however, be found difficult to prevent the heel from being drawn away from the bandage, and stretching of the tendo Achillis will by this method be tedious.

This method has the disadvantage of being tedious, but it has many advantages in being a practical method, readily applied, and not leaving details of application to the patient's parents. It is evident that correction in this way, if persistently applied, is possible. If the Chinese[1] can produce an extreme deformity by bandaging the children's feet, the same method could be employed for the correction of deformity, but this can be done only at the expense of considerable time and patience.

Mechanical (without tenotomy) correction by means of appliances or elastic straps has been successfully employed in very young cases. The method, however, requires much persistence on the part of the surgeon, if a perfect cure is expected.

An excellent appliance for the correction of infantile club-foot has been devised by Beely. A slight modification of this will be seen in the accompanying pictures (Figs. 347, 348). It is light, not expensive, and can be used very readily by the mother or nurse. The method has been used by the writers chiefly in infantile cases, but it has also been employed in older children.

Two steel strips, of a strength varying according to the case, are cut

[1] Descriptions of the method of the Chinese have been given from time to time by travellers. It would appear to consist of tight bandaging of the foot. The bandages are soaked in a preparation of benzoin and are wound successively around the foot as tightly as possible. The toes drop off occasionally from gangrene. There is great pain at first, but subsequently it diminishes. The process is continued for a year or more.

of proper length and connected by an ordinary joint allowing free motion. The upper end of *B* is connected with a bent strip of tempered steel long enough to encircle half the patient's pelvis, a leather strap *F* completing the circle. The lower end of *A* is bent so as to pass under the foot, and has two buckles, *G H*, to receive adhesive plaster on the patient's leg, used for the purpose of keeping the heel well in the appliance. A cross steel strip *D*, padded, passes in front of the leg above the ankle, and with a strap which goes behind holds the leg from slipping forward or

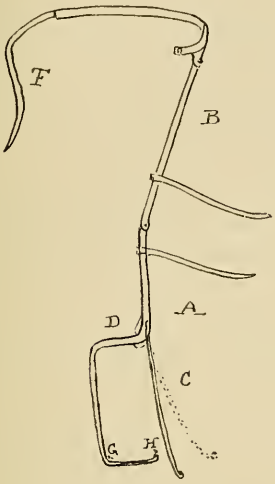

FIG. 347.

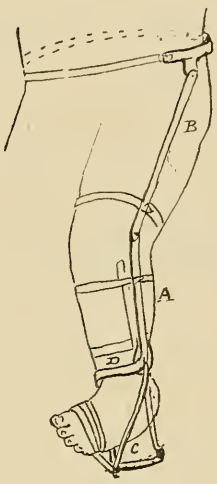

FIG. 348.

FIGS. 347 and 348.—Modified Beely Correcting Appliance.

backward. A steel rod *C* projects to the outer side of the foot. It should be strong enough to stand ordinary strain, but soft-tempered and capable of being bent by a wrench; it furnishes the point from which a pull upon the deformity can be made. A small padded plate, *I*, protects the pressure which falls upon the side of the astragalus and os calcis. The limb can in this way be firmly held in the appliance. The child cannot kick it off, and there is no pressure on the dorsum of the foot to cause pain or sloughs.

The pull upon the foot is effected by means of a strip or strips of adhesive plaster wound about the foot at the level of the ball of the toes, the free end being long enough to reach the end of the arm *C*, which can, if desired, be furnished with a buckle, into which the webbing sewn on to the end of the plaster can be buckled, or the plaster alone may be wound over the end of the steel rod. If it is desired to furnish elastic tension, elastic webbing can be used; but a continued pull, increased by tightening as the deformity is corrected, will be found satisfactory.

To protect the inside of the great toe from being cut by the pulling adhesive plaster, it can be covered by a strip of smooth leather; and to prevent the adhesive plaster from slipping back, a second strip of plaster can be wound close to the first on the proximal side of the foot.

The side arm *C* is to be bent as the foot is corrected, the end being placed at the point from which it is desired that the pull should come. If desired, the arm *C* can be connected with the upright *A* by means of a double screw joint, so that motion and direction of the arm can be regulated by key. This, however, increases the expense of the appliance without adding to the efficiency. Thorough abduction of the foot should precede elevation or correction of the rotation. Instead of the plasters pulling upon the foot, bandages can be used, bandaging the foot to the arm *C*. If holes are cut in the stocking and shoe so that the free ends of an adhesive plaster may pass through, the appliance can be used with the patient wearing shoes and stockings.

The efficacy of the appliance depends chiefly on the handiness used in applying it. No especial skill is required to tighten the straps; and this can easily be left to the nurse, with the direction that the side straps should be kept as tight as possible. The adhesive plaster should be changed every three or four days, and this can be done by the nurse without difficulty. Some skill is required in designing and fitting the appliance, it being essential that the foot and leg are well held in it, and that the steel is strong enough.

Correction by Means of Straps and by an Elastic Force.—The use of an elastic force to overcome contraction can be employed in the correction of club-foot as of other deformities. It has been recommended by Davis and Barwell and Sayre.

Various appliances have been devised to employ elastic correction, and on the theory that the elastic force supplemented the weaker muscles, the method was regarded as physiological; but though the method will be found of use in some of the lighter cases, yet it has not seemed to the writers superior to other ways of mechanical correction.

The amount of the force can in a measure be increased by securing the foot to a flat thin board, longer than the foot and wider at the outer edge, and attaching the elastic straps to the farthest points of the board; but even with the advantage of mechanical leverage thus obtained the treatment demands time and is an annoyance which can be avoided by tenotomy.

Thomas, of Liverpool, and Taylor, of New York, have both demonstrated that, if the foot can be prevented from twisting or rolling by any appliance, the weight in walking in a child of any size, if thrown fairly upon the foot, will act in correcting the equinus deformity. To do this effectually the knee should be kept from bending. This method will not be efficient in cases of extreme equinus, but it will be found a help in

cases with moderate contraction. The same may be said of the method of mechanical stretching of the tendons by means of appliances furnished with geared joints moved by a key. More speedy and efficient means of correction are now available than when tenotomy was considered a grave operation.

Combined Operative and Mechanical Method of Treatment.—A combination of operative and mechanical methods of treatment is at present the most common mode of treating club-foot of all ages. The operative interference most frequently resorted to is tenotomy and subcutaneous division of the fasciæ or ligaments.

Tenotomy.—Delpech, guided by accidental section and ruptures of the tendon, was the first to define the indications for a scientific tenotomy, and thus made an important advance in the treatment of club-foot. Stromeyer, Bouvier, Guerin, Little, and Adams have made the operation popular and within the reach of every surgeon.

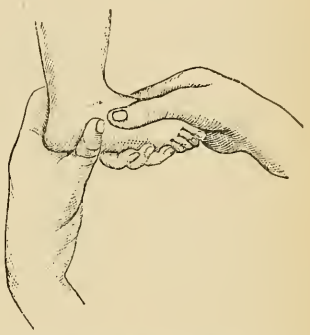

FIG. 349.—Position of Hands in Holding Foot for Tenotomy of Tendo Achillis.

The tendons may be divided by entering the tenotome under the skin and cutting the tendon from without inward, or by passing the tenotome under the tendon and cutting outward. The advantage of the former is that there is no danger of making through the slit of the tendon a large skin incision. There is, however, danger of incomplete cutting of the tendon. Bouvier calls the two methods of procedure sub- and supratendinous section, and according to this surgeon a choice is a matter of indifference, but the subtendinous method is sometimes to be preferred as the most simple in its execution and one permitting complete section of the tendon without risking the skin. The supratendinous method is to be preferred when the tendons are not very salient, as in young children, or in tendons close to the bone or in the neighborhood of vessels and important nerves. The tendon which is most frequently divided in equino-varus is the tendo Achillis.

Section of the Tendo Achillis.—The patient should lie upon his face and an assistant should hold the foot; the surgeon, having made a longitudinal fold of the skin, enters the knife parallel to the border of the tendon, passing the tenotome flatwise between the tendon and the skin. This having been done, the blade of the knife is turned toward the posterior surface of the tendon and the assistant raises the end of the foot so as to stretch the tendo Achillis slightly. The left index finger presses on the skin over the back of the tenotome, and in this way the sensation of the cutting of the tendon can be felt.

The only precaution necessary is to be assured that the tendon is completely divided. When the operation is done, the extravasated blood is squeezed out of the opening and a small amount of aseptic cotton is placed over the wound. The operation should be done aseptically and an aseptic dressing applied.

Section of the Tibialis Posticus.—Section of the tibialis posticus is done in the following way: If the muscle is divided in the leg, the foot is placed on its external border. The surgeon divides the skin by means of a pointed tenotome 2 cm. above the tip of the internal malleolus and on a vertical line situated half-way between the posterior border of the malleolus and the corresponding border of the tendo Achillis. The tenotome should be directed perpendicularly downward to the depth of 1 or 1.5 cm. Then the handle of the instrument should be turned so as to describe the arc of a circle and the tendon divided vertically inward. This having been done, the tenotome is withdrawn and a blunt-pointed one inserted. This should be directed so as to pass behind and under the tendon of the tibialis posticus, and then it is sufficient to turn the cutting edge forward and to move the instrument gently forward and back, while the assistant at the same time turns the foot forcibly in the direction of abduction.

If the incision is made too near the malleolus, the internal saphenous vein and nerve may be cut. If the incision is made too near the tendo Achillis, there is danger of dividing the tendon of the long flexors of the toes and the posterior tibial artery and nerve. Bonnet thinks he has wounded this artery more than once, but without serious injury. To avoid this possibility, Velpeau advised cutting the tendon of the tibialis posticus on the foot from a line extended from the top of the internal malleolus to the scaphoid, but this is not easily done in infants.

The writers can record the puncture of the posterior tibial artery by the point of a tenotome and the formation of a small aneurism which required ligation, but caused no subsequent annoyance.

The Tendon of the Tibialis Anticus.—The tendon of the tibialis anticus is divided more easily. For this purpose it is sufficient to be guided by the prominence of the tendon put on a stretch by abducting the foot. To avoid the wounding of the deep parts, it is better to enter the tenotome under the tendon.

Division of the Plantar Fascia.—It is often necessary to divide also the plantar fascia, preferably before division of the tendo Achillis, as the latter acts as a means of support for stretching the foot when the plantar fascia is divided. The plantar fascia is divided in the same way that the tendons are incised. The most prominent portion of the fascia is the point of election for subcutaneous incision. The fascia, it must be borne in mind, is not a narrow band, but a broad ligament needing a long subcutaneous incision. The tenotome should be inserted

on the inner side of the sole nearly half-way between the os calcis and the ball of the foot, but nearer to the os calcis. The tenotome is to be pushed subcutaneously nearly across the sole, the edge of the knife turned toward the fascia, and the knife drawn across the fascia, which will be felt to give way as it is divided; an assistant should make upward pressure upon the ball of the foot, in order to put the fascia on the stretch. As the artery lies deeply, there is no danger of injuring it, if ordinary care is used.

The tenotomes used should be strong at the neck, and the cutting edge should not be too long, as the skin is necessarily divided if they are too long; a cutting edge is used in operating on infantile cases, which

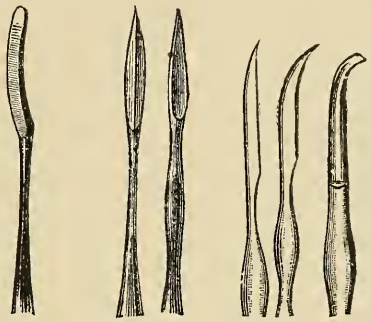

FIG. 350.—Different Forms of Tenotomes.

require a much smaller instrument. Tenotomes should be of two sorts, one with a short, pointed end, for thrusting into the skin and under the tendon, and a blunt-pointed one which can follow where there is danger of wounding an artery by a sharp point. Curved tenotomes are sometimes of use, especially for division of the scapho-astragaloid ligament.

Tenotomes as furnished by instrument makers are ordinarily much too large, and though serviceable in myotomy, are better for tenotomy in children if smaller than is indicated in the accompanying cut. The neck should be strong, as the breaking of the tenotome in the wound (an accident which once happened in the experience of the writers) gives annoyance.

The Repair of Divided Tendons.—The reparative process of divided tendons has been made a subject of numerous investigations, since Hunter's original experiments in 1767, and has been studied with much care by Mr. Adams, and later by Tubby.[1] When a tendon is divided, the cut ends are separated to a variable extent, depending upon the retraction of the muscle to which it belongs, upon the position in which the limb is placed, and upon the surrounding attachments of the tendon.

[1] "Orth. Surgery," 1896, p. 321.

Extending beneath the ends of the tendon is its tubular sheath of connective tissue, and it is this which chiefly furnishes the reparative material.

The sheath becomes vascular and succulent, and after the absorption of any blood that may have been effused within it, the interval between the divided ends of the tendons becomes filled with lymph, which gradually becomes fibrillated and forms a firm bond of union between them.

The new material so closely resembles the old tendon and is so intimately blended with it that for a time it would be difficult to distinguish them, except for a certain translucency which is possessed by the former, and is not natural to the latter. By this means the divided tendon is increased in length to the extent of the interval by which its ends are separated, and elongation will vary according to the amount of separation.

If after the operation treatment is carried out with ordinary care and skill on a healthy subject, a perfect, useful muscle of the normal length is obtained.

Adhesions may, and doubtless often do, form between the divided tendons and the surrounding structure, but in ordinary cases they are not of consequence, for they give way to the manipulation of use of the foot, and do not interfere with the function of the muscle.

Much undeserved opprobrium for a time fell upon the procedure of tenotomy. In half-cured and relapsed cases atrophy and functional disability of the muscles will be found; but there is no evidence to demonstrate that tenotomy, when properly performed, exerts an unfavorable influence upon the muscle.

Division of the Ligaments.—Division of the ligaments has been regarded as useful by many operators. Parker and Shattuck have called especial attention to the importance of this use of the tenotome.[1]

For division of the astragalo-scaphoid ligament, the skin and soft tissues should be punctured down to the bone by the insertion of the tenotome. It should then be inserted in front of the internal malleolus and pushed directly to the underlying bone, and swept subcutaneously around the bone, keeping close to it. The knife should be kept between the skin and ligaments, and the latter divided by a sawing motion of the tenotome. This division, if satisfactorily and thoroughly made, may serve in certain cases as a substitute for the division of the tibialis tendons.

The calcaneo-cuboid ligament should also be divided in severe cases. The tenotome should be inserted a short distance behind the head of the fifth metatarsal bone, near the articulation of the os calcis and cuboid, which can be felt on palpation. The sharp-pointed tenotome should be inserted to the bone, and then by careful motion the whole ligament should be divided.

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[1] London Path. Soc., British Med. Jour., 1886, vol. ii., p. 10.

The age at which patients should be operated on is a matter of judgment and should depend upon the child's condition and nutrition.

The reputed growth of a child's foot is indicated by the measurements of Quetelet and Langer. A child 3 months old has a foot 75 to 85 mm. long, at 6 months 101 mm., at 1 year 107 mm., at 15 months 112 mm., at 18 months 116 mm., at 20 months 119 mm., and at 21 months 122 mm. That is to say, the foot increases with less rapidity the older the child grows, and if the foot is left to itself the deformity greatly increases in the first months of life. It is therefore rational to claim that the sooner the foot is corrected the better, provided the patient's general condition is satisfactory, and that treatment is not liable to be interrupted by intercurrent infantile disorders; practically, treatment should be undertaken as soon as an infant is nursing well and is in reasonable health.

Subcutaneous tenotomy of all the parts which obstruct the complete restoration is performed. This in most cases consists of division under an anæsthetic of the plantar fascia, the tendons of the tibialis anticus and posticus, the ligament of the scapho-astragaloid joint, and last, the tendo Achillis. After the tenotomy of the first three the foot is forcibly corrected by the hand, and a division of the resisting parts carried to such a point that the foot can be easily brought beyond the normal plane, after which tenotomy of the tendo Achillis is done and the foot placed in plaster.

These plaster bandages are left on for an interval of from ten days to three or four weeks. In case the restoration has not been perfect, as sometimes happens with more resistant feet, it is well to remove the plaster at the end of ten days or two weeks and apply the shoes (to be described), reapplying the apparatus every two or three weeks. In this way, before complete consolidation has taken place, a certain amount of gain can be made and over-correction be obtained at the end of a few weeks which at first was impossible. If, however, the restoration has been complete it is better to keep the bandages on for from six to twelve weeks in order that the foot may not be disturbed from its over-corrected position. When the bandages are removed great care should be taken that the foot is not allowed to drop from its over-corrected position, and thus make traction on the ligaments and soft parts in which contraction is desired.

When the plaster bandages are removed a retention appliance, to be described later, is to be used so long as there is any tendency to an incorrect position.

The permanence of the correction depends on the establishment of an accurate balance of the antagonism of muscles and other soft parts when the foot is in normal position. The after-treatment by retention must be persisted in until the child is able, without special effort, to walk with the foot in a natural position, otherwise a relapse will occur.

In resistant cases the following radical measures have been employed:

1st. Open incision.

2d. The use of extreme force.

3d. Tarsal osteotomy.

4th. Tarsal resection.

The chief difficulty is in obstinate cases to stretch the contracted tissue on the concave side of the distortion. Acting on this belief, Dr. A. M. Phelps has, by a direct open incision on the inner and plantar surface, corrected severe cases, and has favored this method of treatment.

The advantage of open incision in club-foot is the facility of complete and thorough division of all the soft tissues to the bone. The method by which this is done is as follows: The skin is divided along the inner side of the foot, from the tip of the malleolus well down on the inner edge of the first metacarpal bone. After the skin is incised, the other tissues are cut with care, using a director if necessary. The insertion of the tibialis tendon is found and cut across. The artery can be spared by careful dissection, but if necessary it can be divided and tied. The plantar fascia on the sole of the foot should be divided by the use of a tenotome, or long thin knife. A cross incision toward the sole of the foot from the middle of the long incision is sometimes necessary, but it is desirable to avoid this if possible. A triangular incision instead of the cross-cut of the skin and fascia is recommended by Jonas[1] to diminish the gap after correcting the foot.

Even if tenotomy and thorough open incision are done a certain amount of resistance remains from the interosseous ligament connecting the tarsal bones. Considerable force is often necessary to bring the foot into an over-corrected position. This can be done either by manual force or by the aid of mechanical force. Several wrenches for this purpose have been devised; that of Thomas is the simplest and is sufficiently efficient when no bone obstruction exists. The foot is then brought into as normal a position as possible, thorough aseptic dressings are applied, and the foot is then fixed in a plaster-of-Paris bandage reaching above the knee and holding the well-padded and aseptically dressed foot in an over-corrected position. If the dressing is provided with efficient protectors and sufficient dressings, no change in the bandage need be made for a fortnight or longer. If necessary, however, a window can be cut in the plaster over the wound and the dressings changed. After the plaster of Paris is discarded the retention shoe is to be worn.

Of this method it may be said that healing by organized blood clot is, to those who are proficient in aseptic surgery, almost certain, and the method is therefore free from danger.[2]

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[1] Jonas. Annals of Surgery, April, 1897, 449.

[2] Phillipson: Deut. Zeitschr. f. Chir., xxviii.

In applying the bandages, it is of course important that the foot should be held in a corrected position, or an over-corrected position, until the plaster becomes hard, as no further correction can take place under the bandage. In the majority of cases perfect correction or over-correction is possible, and the foot can be held in proper position for the application of the fixation bandage without much force.

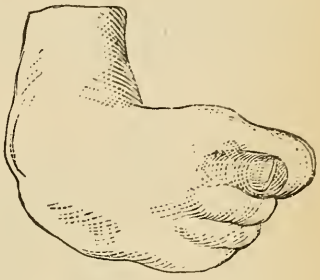

FIG. 351.—Foot before Correction.

Krauss, as an aid to support by plaster bandages, makes use of a wooden sole plate with a steel upright on the inner side of the leg and an arrangement for increasing the pressure for the inner side of the metatarsal and great toe. The appliance is covered with thick felt, and the foot and ankle are secured to the wooden sole plate by means of a plaster-of-Paris bandage applied over a stocking, and without much cotton applied to the foot.

The writers would agree in the statement that forcible rectification is able to correct and cure the severest forms of club-foot, but they have found mechanical correction more reliable than simple manual force.

The accompanying cuts (Figs. 352, 353, and 354) indicate relapsed and resistant cases of congenital club-foot. The boy was fourteen years of

FIG. 352.—Foot before Correction.

FIG. 353.

FIG. 354.

FIGS. 353 and 354.—Foot after Correction.

age; the foot was corrected at one sitting, necessitating the use of a plaster bandage to the corrected foot for two months. A walking appliance was furnished and no further treatment other than occasional inspection for six months was necessary, and the cure had remained permanent when last heard from, three years later.

The cast of the girl's foot was taken at the age of ten. Two rectifications were needed and a direct treatment of four months. The drawings, from a photograph, indicate the condition of the feet when the child was thirteen, no appliance having been worn for two years (Figs. 351, 355, and 356).[1]

Operation upon the Bones.—When but a slight amount of osseous distortion is present forcible correction aided by tenotomy or open inci-

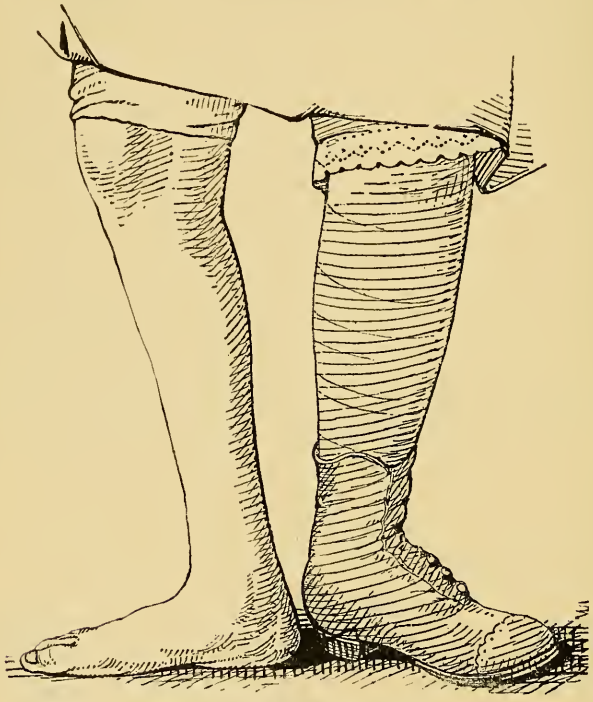

FIG. 355.

sion will be sufficient to overcome the deformity, but in the more resistant cases changes in the shape of the tarsal bones forming the mediotarsal joint prevent perfect cure, and operation upon the bones is necessary.

Excision of the Tarsus.[2]—Dr. Little, of London, was the first to suggest removal of a portion of the tarsus (the cuboid bone) as a means of shortening the treatment in "inveterate varus."[3] This was done, in 1854, by Mr. Solly, of St. Thomas' Hospital, at the recommendation of Dr. Little; the result was less successful than was anticipated, owing,

[1] Wolff uses the silicate bandage as a walking-appliance, but it is manifestly more cumbersome and unsightly, and therefore less useful, than the Taylor varus shoe.

[2] H. A. Wilson: Orth. Trans., vol. vi., 159.

[3] "Practical Observations on the Treatment of Club-Foot," third edition, p. 305.

apparently, to the difficulty encountered in maintaining the corrected position of the foot by means of the appliances used. The patient recovered from the operation.[1] Mr. Lund[2] removed the astragalus in a similar case with success. The details have, however, not been given with sufficient accuracy to justify a clear opinion as to the perfection of the cure. Dr. Mason, of New York, was obliged to amputate in a case in

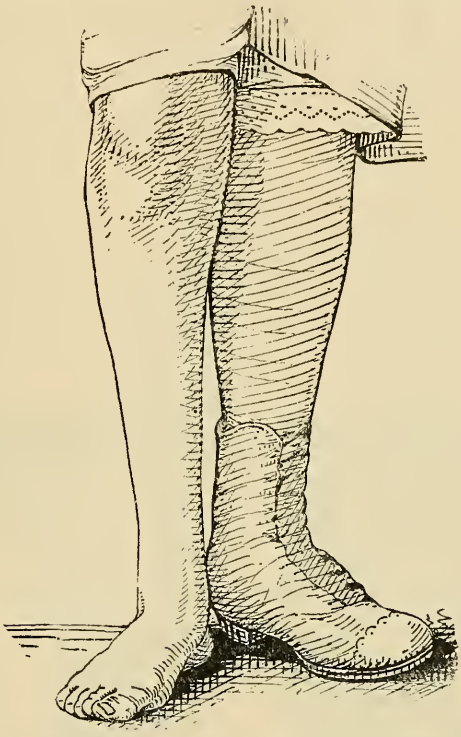

FIG. 356.—Result Two Years after Apparatus was Left Off. Girl of thirteen. Resistant club-foot.

which he had unsuccessfully excised the astragalus[3] and a portion of the external malleolus. Verbelzi successfully dissected out the astragalus in a case of congenital club-foot in a child five and one-half years old.[4] The exact details it has not been possible to find.

Mr. Lund showed before the London Clinical Society a case in which he had successfully removed the astragali in double congenital talipes. The boy was able to walk about readily. The astragalus was excised (after an incision through the soft parts) by means of a gouge and a

[1] Adams: "Club-Foot," second edition, Philadelphia, p. 251.
[2] British Medical Journal, October 19th, 1872.
[3] New York Medical Record, July 14th, 1877.
[4] Centralblatt f. Chirurgie, No. 24, 1877.

short curved hook, with a cutting edge on its concavity. Mr. Thomas Smith and Prof. John Wood have also performed the operation success-

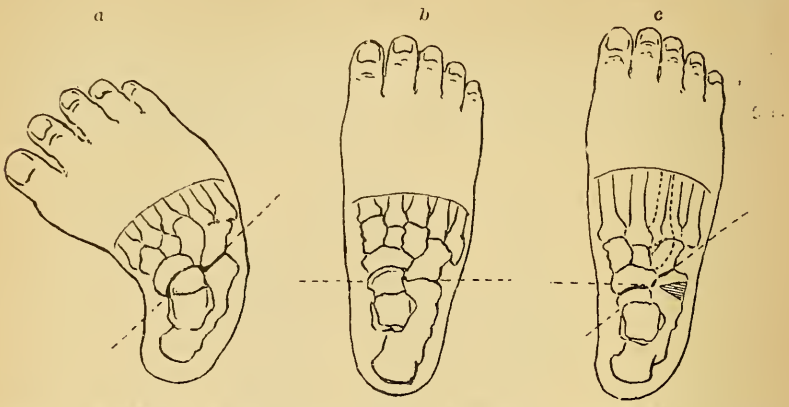

FIG. 357.—Axis of Medio-tarsal Joint in, *a*, Club-foot; *b*, normal foot; *c*, club-foot partly corrected, showing wedge to be removed before correction is complete.

fully.[1] Mr. Davy[2] operated in three cases by removing simply the cuboid bone, and in three cases by excising a wedge-shaped piece from the tarsal

FIG. 358.

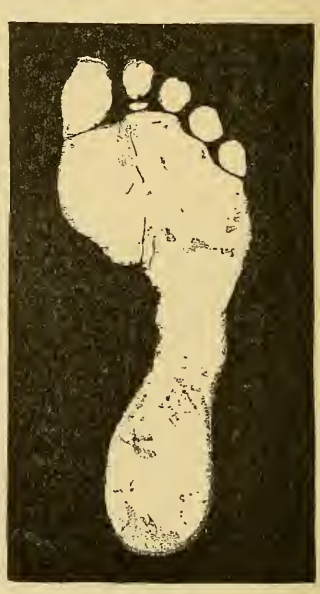

FIG. 359.

FIG. 358.—Imprint of Foot of a Child Sixteen Years Old. Treated when one year old for congenital club-foot.

FIG. 359.—Imprint of Normal Foot.

[1] Lancet, March 16th, 1878, p. 389.

[2] Lancet, February 14th, 1888; Lancet, March 16th, 1878, p. 388; British Medical Journal, December 15th, 1877.

arch. Death from septicæmia occurred in one case. In the others recovery took place, and from the report the cases progressed favorably. Davies Colley operated by resection of the tarsal bones on a child twelve years old; ten days after the operation on the second foot, and twelve weeks after the first operation, the patient was able to walk about without any apparatus. Two months later, when re-examined (no apparatus having been worn in the interval), the foot was found in good position, the boy treading on the whole of the sole. The patient could walk, hop, and jump. Six months later he was able to walk eight miles.[1]

König,[2] Rupprecht,[3] Mensel,[4] and others report, respectively, three, five, and five operations of resection of the tarsus for severe club-foot.

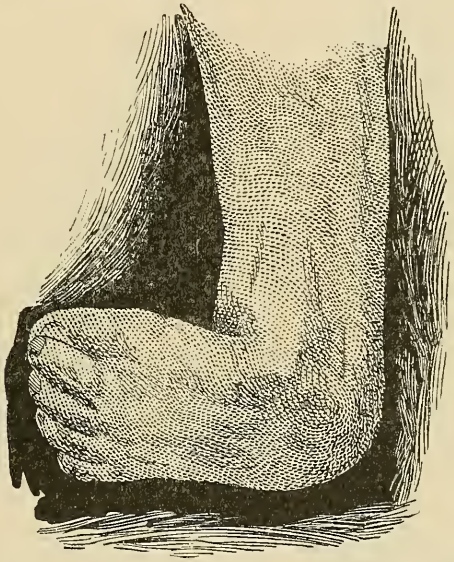

FIG. 360.—From Photograph of a Woman, Thirty-five Years Old, Suffering from Congenital Club-foot.

All are mentioned as successful with the exception of one under the care of König, in which death occurred ten days after the operation. At the autopsy it was found that the patient had been suffering from ulcerative endocarditis, with valvular disease of the heart, and with pathological changes in the lungs.[5]

The methods introduced may be grouped as follows:

1. Removal of the cuboid alone.
2. Removal of the astragalus alone.

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[1] Medico-Chirurgical Transactions, second series, vol. xliii., 1877.

[2] Centralblatt f. Chirurgie, 1880, No. 13.

[3] *Ibid.*, March 13th, 1880.

[4] Centralblatt f. Chirurgie, No. 11, 1880.

[5] Poore: Annals of Surgery, March, 1886, p. 206.

3. Removal of the astragalus and cuboid and scaphoid.
4. Section of the neck of the astragalus.
5. Removal of the astragalus and the external malleolus.
6. Osteotomy of the lower end of the tibia and fibula.
7. Wedge-shaped resection of the tarsus.
8. Osteotomy of the os calcis.

Removal of the cuboid or astragalus alone is insufficient, as in resistant cases of club-foot the os calcis is also involved while the cuboid is

FIG. 361.—The Same Foot One Year after Forcible Correction.

FIG. 362.—Same Foot One Year after Forcible Correction.

but slightly distorted, and the chief distortion of the astragalus is at the medio-tarsal articulation.

A wedge-shaped excision of the tarsus sacrifices bone unnecessarily and is therefore unscientific, and osteotomy of the lower end of the tibia and fibula is neither sufficient nor scientific. Correction by wedge-shaped resection, however, and also by removal of the astragalus can give satisfactory, though not perfect results.

The illustration represents a satisfactory result; the condition prior to operation in the instance of a boy of fourteen is indicated in the drawings from the casts 2 and 4 (Fig. 373), and the result of the operation by drawing from the casts 1 and 3. Both feet were operated upon and the functional

result may be determined by the illustration reproduced from the photograph (Fig. 373). It may be added that the boy was seen at the age of nineteen and had been able for several years to engage in an active occupation, and was able to walk without cane or ankle appliance five or ten miles.

Astragaloid Osteotomy.—An examination of the anatomy of resistant club-foot shows that the facet of the astragalus in the astragalo-scaphoid articulation is on the side instead of in front. There is also some obliquity of the neck of the astragalus. If this obstruction of the bone can be corrected and the front of the foot brought into place, there would be no tendency to relapse.

FIG. 363.—Sole Imprint of Same Foot as in Fig. 360, Three Years after Forcible Correction.

It is essential, in every inveterate case of club-foot, that if the foot is to be unfolded, the shortened tissues in the arch of the foot and in the inner side of the foot be stretched, torn, or divided. This can be done safely by means of tenotomy, forcible stretching, or open incision; but the deformity of the astragalus still remains. In many cases, even if somewhat resistant, if the deformity is rectified and the foot held a sufficient time in the proper position, and a proper walking shoe used for a year, a new facet of the astragalus will be formed and a cure effected. In a few cases this is not the case, and in such instances osteotomy of the neck of the astragalus suggests itself as a suitable operation.

FIG. 364.—Congenital Club-foot in a Boy Six Years Old. (From a Photograph.)

FIG. 365.—After Forcible Correction.

FIG. 366.—Same Case; Walking Apparatus Applied.

The procedure will not be found a difficult one. Tenotomy or open incision and division of the fascia and ligaments should be done, and the

FIG. 367.—Sole Imprint after Removal of Astragalus for Club-foot.

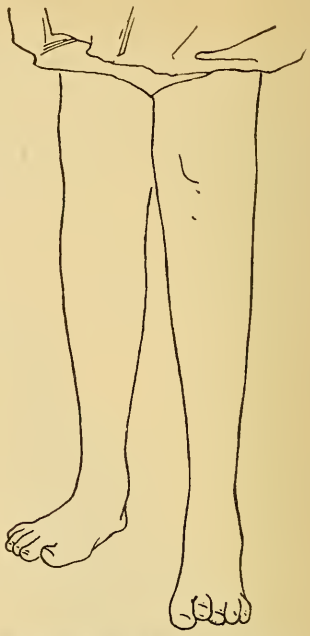

FIG. 368.—From Photograph after Removal of Astragalus of Left Foot for Club-foot.

FIG. 369.—From Photograph after Removal of Astragalus.

foot stretched and manipulated into as nearly normal a position as possible. An incision through the skin is made from the tip of the malleolus to the inner side of the head of the first metatarsal, which will be found in severe cases close to the malleolus. The incision is close to and nearly parallel to the tibialis anticus tendon, and in the direction of the metatarsal. The incision should be made to the bone, and the foot straightened, as the metacarpal bone is separated from the malleolus. The scaphoid will be seen before the astragalus is encountered, if the deformity is great, and it will be first within the reach of the knife in all cases. If the foot is still further stretched, the scaphoid begins to uncover the side of the astragalus, and the neck of the astragalus is seen; a small osteotome is entered and placed upon the neck of the astragalus, to the proximal side of the scaphoid articulation, and the neck of the astragalus divided or nearly divided. The foot is then forcibly straightened, and the neck of the astragalus unchiselled is fractured. The result is

FIG. 370.—Sole Imprint of Case of Club-foot Corrected by Tenotomy, without Contraction but with Inversion of the Foot.

FIG. 371.—Imprint of Left Foot before Operation.

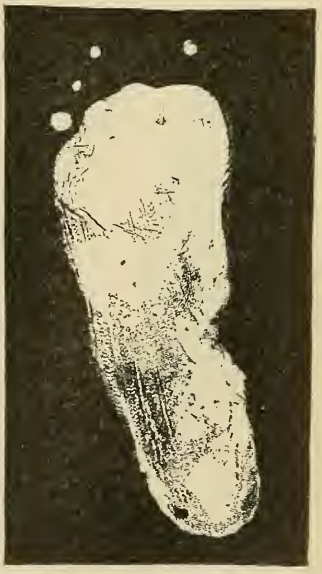

FIG. 372.—Imprint of Left Foot after Operation.

similar to that in Macewen's operation for knock-knee, and the distortion at the neck of the astragalus is removed. It is manifest that the line of section of the bone at the neck of the astragalus should be transverse to

FIG. 373.—Drawn from Casts before and after Excision. 2 and 4, Before excision; 1 and 3, after excision.

FIG. 374.—Imprint of Right Foot (Congenital Club-foot) before Operation.

FIG. 375.—Imprint of Right Foot after Operation. Osteotomy of neck of astragalus and os calcis.

the axis of the bone, and at such a plane that when the equinus deformity is corrected the resulting gap at the section should not be greater than necessary. Strict asepsis is essential. The foot should be fixed in a corrected position. A wedge-shaped resection of the neck of the astragalus through a skin incision in the outer and upper surface of the foot has been performed, but linear osteotomy would seem to be preferable.

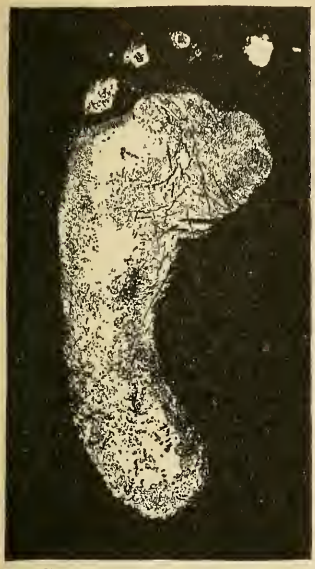

FIG. 376.—Imprint after Osteotomy of Neck of Os Calcis and Astragalus.

Osteotomy of the Head of the Os Calcis.—The relation of the cuboid to the os calcis is frequently masked, lying deeper than that of the scaphoid and astragalus, and it may in treatment be but partially corrected. The distortion of the os calcis at its anterior aspect, if not corrected, increases and forms an obstacle to the complete restoration of the cuboid to the normal position, although the rest of the deformity may have been corrected.

When the cuboid is cartilaginous and the ligaments are well stretched, the defect at the anterior portion of the os calcis can be overcome by forcibly correcting the foot and retaining it in

FIG. 377.—From Photograph before Operation in a Boy of Twelve.

FIG. 378.—Same Case after the Operation. Osteotomy of neck of astragalus and os calcis.

the corrected position by means of a plaster-of-Paris bandage, care being taken, however, that the cuboid be restored to place, and in time it will

be found that the cartilaginous abnormality in the shape of the os calcis is gradually changed under corrected pressure.

When distortion of the head of the os calcis is great, no amount of mechanical treatment can overcome the obstacle, if it is of bone and if the ligaments are strong, binding the bones in a distorted position. It is manifest under these circumstances that the rational treatment is a removal, not of the astragalus or cuboid, but of a part of the projecting portion of the head of the os calcis (Figs. 371, 372, 374, 375).

The operation is not a new one, but some of the details are not so generally known as is desirable. After complete stretching or division

FIG. 379.—From Photograph Two Years after Tarsal Resection.

by tenotomy, force, or open incision of the contracted tissues on the inner and under side of the foot, tendons, ligaments, and fasciæ, if it is found that the front of the foot cannot be brought to a perfectly corrected or over-corrected position, an incision should be made on the outer side of the foot, passing from behind the external malleolus forward and downward. The incision should be a curved one, and the chief convexity should be at the forward portion of the os calcis. This incision should reach to the bone, and should expose the peroneal tendons. These can either be drawn to the side, or divided to be stitched later. The upper portion of the incision should reach behind the external malleolus, and should extend far enough up to allow sufficient retraction of the flap to give room for the osteotomy. After the bone has been reached, the peri-

osteum divided and pushed aside, an osteotome should be inserted far enough back to remove a sufficient amount of bone. The direction of the insertion of the osteotome should be such as to allow the placing of the cuboid, after the bone has been removed, in a normal position. This step of the operation requires some nicety and judgment, as it is of importance that the front plane of the bone, after the wedge has been removed, should be in the direction of the normal facet of the front of the os calcis. A wedge-shaped portion of bone should be removed from the anterior and outer part of the os calcis, and the cartilaginous ends saved in order to allow a proper amount of motion between the cuboid and the os calcis after recovery. The wedge-shaped portion of bone that should be removed should be ample and enough to allow the replacement of the front of the foot in a normal or over-corrected position and the restoration of the proper direction of the os calcis.

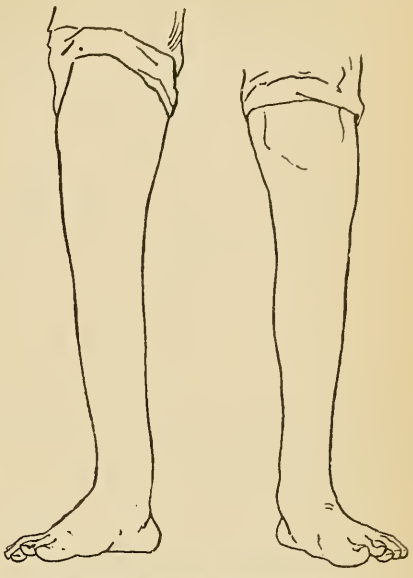

FIG. 380.—Drawn from Photograph after Operation. Double osteotomy of neck of astragalus and os calcis.

The wound should be carefully washed out to remove any fragments of bone that may have been left, and subsequently stitched; the tendon

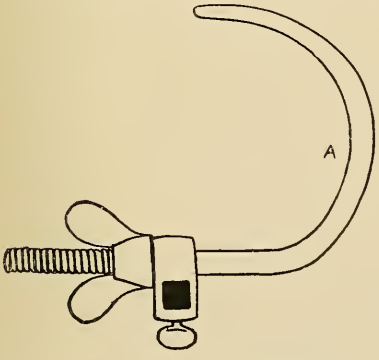

FIG. 381.—*A*, Diagram of Half-circle.

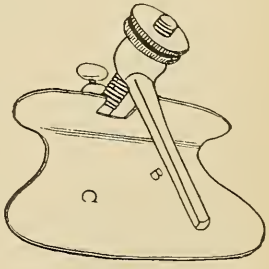

FIG. 382.—*C*, Sole Plate.

of the peroneus longus, if divided, being stitched. The foot should then be dressed with proper dressings and fixed in an over-corrected position by plaster bandages according to the ordinary rules in osteotomy.

Whether this operation should be done in connection with an osteotomy of the neck of the astragalus, and with an open incision at the same sitting, is a matter of judgment in each case.

Imperfect results are due to neglect of thorough asepsis, failure to

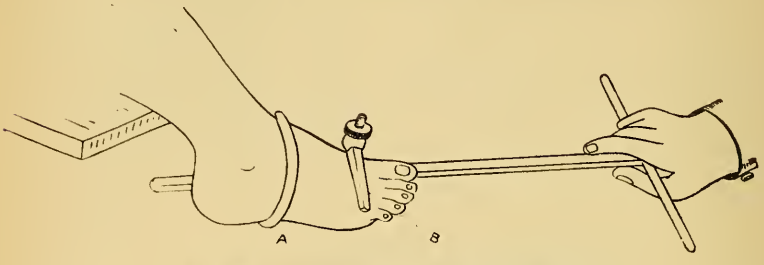

FIG. 383.—Lever Correction Apparatus (Applied).

remove a sufficient amount of bone, failure to remove it in such a direction as to cure the deformity, and lack of care in placing the foot in a corrected position after operation.

Plaster bandages should be applied from the toes to above the knee, which is slightly flexed, to secure the bandage from twisting. While the plaster is hardening the cuboid is pressed upward and outward, and the front of the foot pressed outward and upward, counter pressure being applied on the astragalus on the outer and upper side, and the os calcis twisted into its normal position.

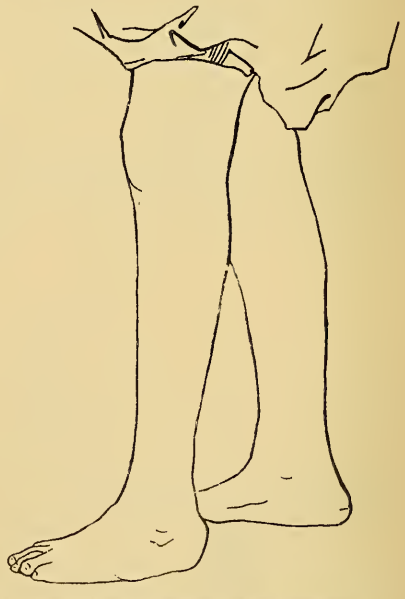

FIG. 384.—From Photograph after Removal of Astragalus of Left Foot.

Treatment can be carried out with a plaster-of-Paris bandage until the foot is thoroughly healed, and also until locomotion has been re-established.

Walking Appliances, Retentive Appliances. — Whatever method of treatment be employed, some form of appliance will be needed after correction to retain the tarsal bones in proper position until the muscles and ligaments have adapted themselves to the normal position, and until articular facets have been formed in the proper direction, or the astragalus and os calcis have assumed, under altered pressure, a relatively normal shape. It is

manifest that a retention appliance is needed for a shorter time after osteotomy is correctly performed than after other methods of correction.

FIG. 385.—Congenital Club-foot.

FIG. 386.—The Same Case; Result of Treatment.

The corrected foot tends to relapse in two directions—inversion and elevation of the heel. If this is unchecked and walking is done in improper attitudes, hurtful pressure and strain fall upon the bones and ligaments of the foot, and relapse takes place. This should not occur if proper retention and walking with a proper attitude of the foot are cared for.

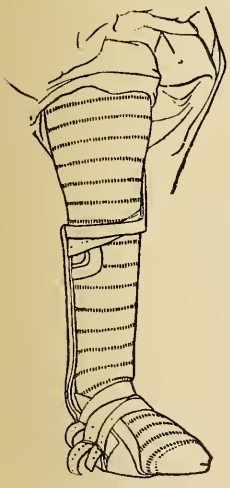

FIG. 387.—The Same Case, with Appliance for Correction.

As these appliances are to be worn a long time, they should be light, readily adjusted by the nurse, not unsightly, and in no way limiting locomotion, walking, or running. The best are worn within the shoe.

FIG. 388.—Sole of Corrected Foot.

The length of time during which the appliance is needed in after-treatment varies and is in general in inverse proportion to the size of the foot or the difficulty of correction, infants in arms needing a retention appliance relatively longer than is necessary in adult cases, in which if correct gait, with proper weight bearing upon the sole, is secured for a few months relapses are not to be expected.

It is unnecessary to describe all the various retention appliances that have been used. Mention will here be made of one which has been found

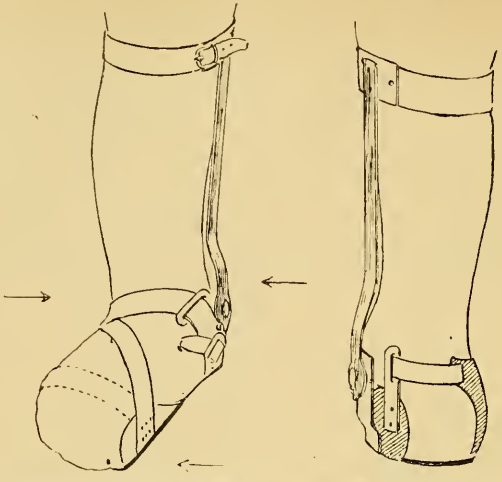

FIG. 389.—Club-foot Shoe, from Front and Back. Arrows show direction of force exerted by straps.

of service in the writers' experience, after a careful trial of the usual varieties of appliances designed for the purpose.

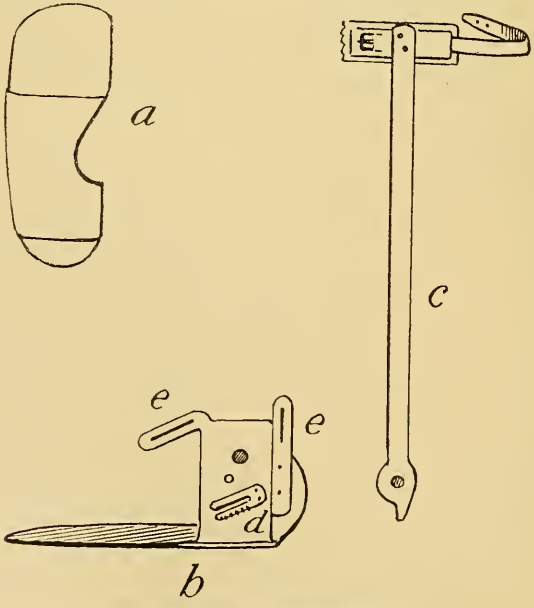

FIG. 390.—Details of Construction.

It is to be remembered that a retention shoe should be as little unsightly and cumbersome as possible, should allow the motion of the foot

needed in correct walking, but should prevent inversion of the front of the foot or raising of the heel and inner edge of the foot. As in some instances the appliance is to be worn for some time, it is convenient to have it worn inside of the shoe, and the appliance is less unsightly.

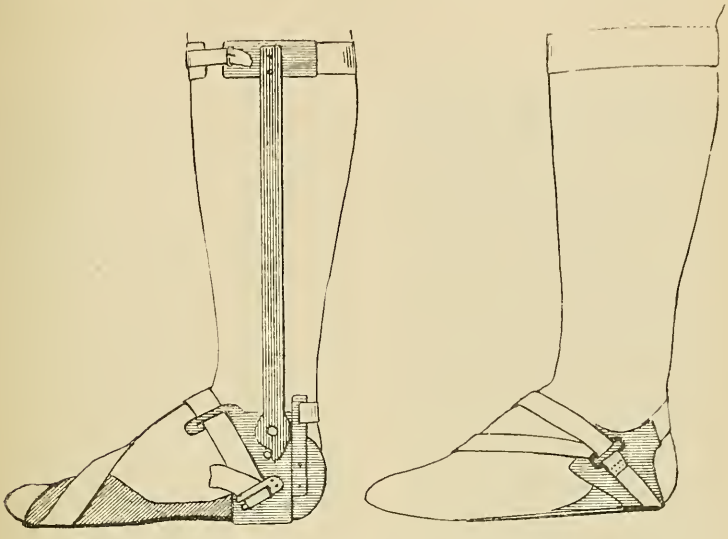

FIG. 391.—Inner and Outer Views.

It is to be remembered that in all appliances it is necessary that the pressure preventing a faulty position of the foot should be applied precisely, pressing the front of the foot and tip of the heel outward, the

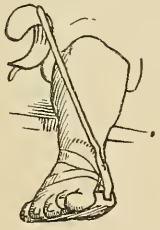

FIG. 392.—Taylor Shoe in Process of Adjustment. The sole plate applied and the foot strapped to the sole plate.

FIG. 393.—The Upright Brought into Place and Acting as a Lever, Turning the Foot to the Outer Side.

front of the foot, especially the outer edge including the cuboid, upward, and the back of the foot, *i.e.*, the end of the os calcis, downward, and the outer dorsum of the foot inward.

Inward pressure should be exerted upon the outer edge of the front of the os calcis and astragalus, and not upon the cuboid, as is too commonly done in inefficient apparatus. As the latter bone is in front of the medio-

tarsal joint, inward pressure upon it not only fails to correct the deformity but tends to increase it. This explains the occurrence of many relapses.

The apparatus (Figs. 389–394), which is a modification of Taylor's varus shoe, consists of a sole plate small enough to fit in a shoe secured with a jointed upright furnished with a stop to prevent the plate from dropping into the equinus position.

FIG. 394.—Varus Shoe. (Children's Hospital Report.)

The foot is secured to the plate by means of a strap which, secured to the inner side of the plate, passes from the inside of the great toe obliquely to the outside of the foot so as to press upon the anterior outer surface of the os calcis and through a loop at the outside, and then is brought across the ankle through the metal loop and secured in the clasp. A cross strap to keep the toes down, and a cross ankle strap to keep the heel down, are sometimes necessary in addition, with a back strap behind the heel.

A simple form of retention shoe can be made by moulding stiffened leather over a cast of the corrected foot and leg and stiffening it with steel sole plate and hinged upright at the requisite joints to prevent the yielding of the leather. This can be laced on the foot and cut so as to allow play at the ankle.

Either of these appliances can be worn inside of a shoe, opened like a bicycle shoe well down to the toes.

Relapses.—No error is greater than a common one, namely, that tenotomy alone is sufficient to correct club-foot. In fact, tenotomy is only the beginning of a course of treatment. If the foot is rectified and held in place for a month, it is supposed by some surgeons that a cure has been effected. But such is by no means the case.

Moreover, it must always be borne in mind that relapses will invariably occur unless the distortion is completely corrected, and in fact over-corrected. In club-foot half-cures are no cures, and little reliance can be placed on the curative effect of time. Efforts at correction should

be continued until the foot can be easily abducted beyond the median line, and while slightly abducted, can be flexed so that the dorsum of the foot shall form less than a right angle with the leg, the sole of the foot being flat, there being no twist in the front of the foot. After this the correction appliance is to be changed for a retention appliance.

Relapses occur in a certain number of cases simply from the careless-

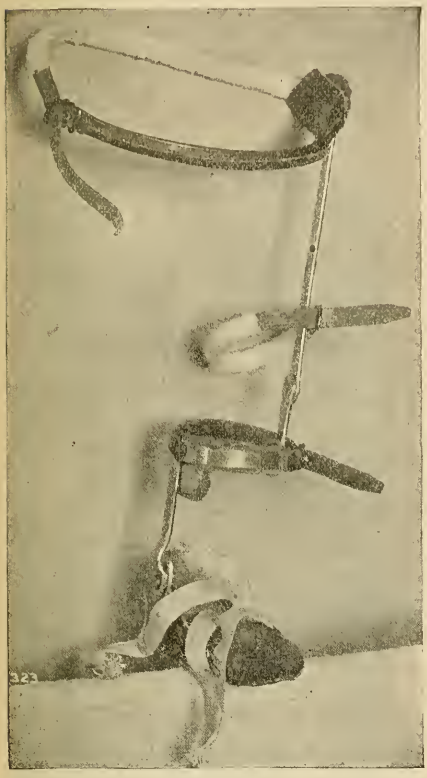

FIG. 395.

FIG. 396.

FIGS. 395 and 396.—Retention Appliance for Club-foot, Unapplied and Applied. (Children's Hospital Report.)

ness of the parents, who are not aware of the necessity of retaining the corrected foot in the proper position for a long time. The foot of a healthy infant in arms is often held in an equinus position, which is often overlooked by the parent.

In cases in which the counteracting muscles are congenitally weaker than they should be, there is, of course, danger that the gastrocnemius muscles may become shortened by adaptive shortening, even if previously of sufficient length, as happens in the case of infantile paralysis. When the foot is large and the child able to walk, the act of walking

aids correction if the foot is prevented from twisting and the weight falls correctly on the sole. But in infants in arms this correcting influence is absent, and the retention appliance needs to be carefully watched until the child walks and walks well. In cases of relapse a second tenotomy is advisable.

Relapses in older children are due to incomplete correction, either from a lack of thoroughness or from the existence of an unusual amount of distortion of the astragalus or os calcis not suspected, and demanding osteotomy, or from too early removal of the fixation appliance.

FIG. 397.

FIG. 398.

FIGS. 397 and 398.—Apparatus Before and After Application of the Bandage. (Children's Hospital Report.)

In some instances of resistant club-foot it is found impossible, in correcting the foot, completely to over-correct the equinus deformity, and to enable the foot to be brought to within a right angle with the leg. If this is not done, inconvenience is felt by the patient in taking a long step, and the foot is turned in to facilitate this. The smaller the foot the greater this danger. If this is not corrected, it may, in some instances, seriously interfere with the perfection of the result.

Relapses in infantile club-foot may also occur from the neglect of a

fixation shoe. In children in arms the feet hang according to gravity, unless the muscles are of normal activity. The muscles in club-foot, even after correction, are not of normal activity; and the feet may relapse and deformity reappear, as in cases of paralytic club-foot. This may also result if the children do not walk correctly when they attempt to walk.

It should always be borne in mind that a distortion in the neck of the astragalus or in the head of the os calcis exists, even in infantile club-foot, and that the feet are not permanently corrected until the alteration of the facets into a normal position has taken place. This is independ-

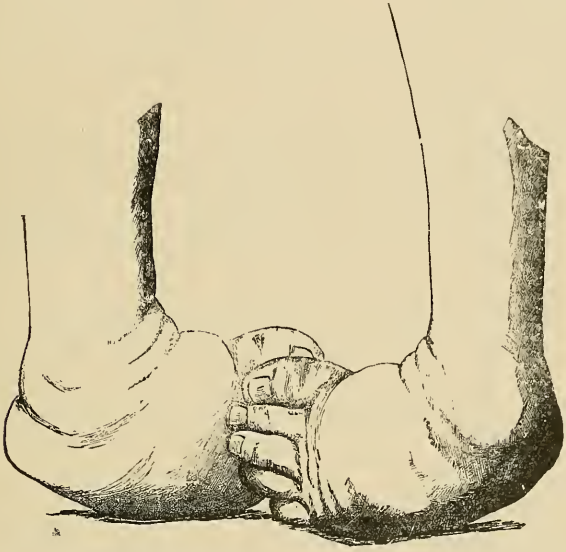

FIG. 399.—Double Congenital Equino-varus.

ent of bringing the foot into a normal position, and demands fixation in a normal position for some time. In some cases this is more needed than in others, probably because the alterations of the facets of the astragalus are in some instances slight.

Imperfect Results.—The obstacles which prevent perfection in result are as follows: Imperfectly divided tendons; imperfectly divided ligaments and plantar fascia; imperfectly stretched ligaments; incorrect relation between the scaphoid and anterior facet of the astragalus, due either to anatomical alteration of shape of the astragalus or to imperfect division or stretching of the ligaments which bind these bones together, in the correction of the deformity; similar incorrect relationship between the cuboid and os calcis.

Too great over-correction of the deformity and the development of a splay-foot have sometimes resulted from over-zealous treatment. The

danger is, however, not great; and instances are rare, and are to be overcome by the treatment for a valgus foot.

Inversion of the foot, after cure of the club-foot, may in a few instances be observed from imperfect strength of the outward rotatory muscles at the hip. This, however, causes but little disfigurement, the inversion usually being slight, and correcting itself by the normal development of the muscles. A marked toeing-in of the foot in running persists a long time in some instances in which the foot is entirely corrected and the walking is normal. It disappears with the increase of muscular strength.

A relaxed state of the knee-joint causing inversion of the tibia is not uncommon in infantile club-foot; it usually corrects itself in the development of the child after correction of the foot. In rare instances, however, it may persist, requiring the longer use of a walking appliance.

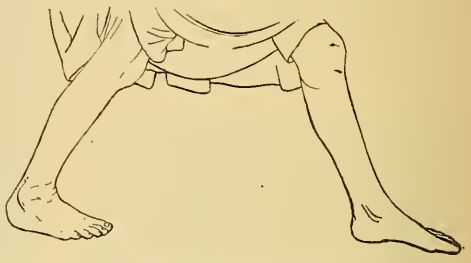

FIG. 401.—Side View at Age of Twelve. Left foot forward, showing amount of motion at ankle.

FIG. 400.—Condition of Feet at the Age of Twelve. Front view.

FIG. 402.—Right Foot Forward.

There appears to be no greater liability to relapse after complete correction by mechanical means than when tenotomy is employed.

The accompanying pictures (Figs. 400, 401, 402) are taken from the photograph of the feet of a child of twelve years born with talipes equino-varus of a severe type. No cast of the feet at the time of infancy was taken, but the feet resembled those in the preceding cut (Fig. 399). Treatment was begun at the age of three months, and was entirely mechanical, and several months were needed for correction, bandages and traction being chiefly employed. A retention appliance was worn for a year and no subsequent treatment was needed.

Treatment of the Muscles.—The muscles retarded in club-feet by disuse need development before a complete cure is effected. Ordinarily the

muscles develop of themselves after complete correction, if the limbs are actively used. In some cases the development is slow and massage and electricity are advisable.

Generalization as to Treatment.—The literature of the treatment of club-foot is too often that of unvarying success. It is sometimes as brilliant as an advertising sheet, and yet in practice there is no lack of half-cured or relapsed cases—sufficient evidence that methods of cure are not universally understood.

Surgeons differ somewhat in regard to the method of treatment of club-foot, but the following statements are regarded by the writers as worthy of acceptance.

First.—That it is possible to correct completely infantile cases of congenital club-feet without the help of any operative interference, even tenotomy.

Second.—Tenotomy, however, even in infants is of assistance, and in older cases is in almost all instances necessary for a perfect cure. Tenotomy properly done is not followed by any unfavorable results.

Third.—Certain resistant cases can be corrected and cured without operation upon the bone, but in many resistant cases considerable force must be used.

Fourth.—In resistant cases, however, when there is deformity of the bone, osteotomy or a wedge-shaped resection of the astragalus or os calcis is necessary.

Fifth.—Congenital club-foot is a thoroughly curable deformity, provided the pathological conditions existing are thoroughly understood, and the resisting structures overcome.

Sixth.—For cure over-correction of the deformity is necessary and retention in an over-corrected position until the normal relation of the parts has been established.

Seventh.—The best retention appliance is one which interferes with the normal motion the least without permitting the distorted position of the foot.

Acquired Club-Foot—Paralytic Deformity.—The most common form of acquired club-foot is that following infantile paralysis which is described in another chapter.

The prognosis of paralytic club-foot is necessarily more unfavorable than that of the congenital form, although the distortion is more readily corrected; it is impossible to restore the affected muscles to a normal condition, and the prolonged use of some form of appliance is generally necessary.

In some instances, however, after thorough correction and retention for a while in a corrected position, if the foot is of sufficient size, relapse does not take place, or only in a partial degree, and a useful and but slightly distorted foot remains.

The treatment of paralytic club-foot is to be conducted on the same principles as that of the congenital type.

Correction is, however, much less difficult, as osseous changes are present only in the old severe and neglected cases.

Operative interference is often unnecessary if thorough mechanical treatment is applied and time is not an object.

But tenotomy of the contracted and healthy muscles can be done as in congenital cases, though over-correction after tenotomy is to be avoided. Immediate correction and fixation in a corrected position are to be used after tenotomy as in the congenital form.

The walking appliance to be used in paralytic cases resembles that which has been described in congenital cases.

Club-Hand.

Congenital club-hand is a rare condition, which is in a measure analogous to congenital club-foot. It is usually found in connection with

Fig. 403.—Club-hand with Deficiency of Part of Radius.

other deformities. The name is applied to a deviation of the hand, at the wrist, from the line of the forearm; and this deviation is almost always in the direction of flexion.

In German, the distortion is known as *Klumphand* and in French as *main bote*.

The modern classification of the distortion is to speak of the cases as dorsal and palmar club-hand, as the deformity is toward flexion or extension; or as radial and ulnar, or cubital, as the deviation is inward or

outward at the wrist. Mixed forms are the most common, and are spoken of as radio-palmar, etc. The dorsal forms are excessively rare. The bones of the arm may be normal, but more commonly they are deformed, or the radius may be wanting wholly or in part. The carpus may be normal, or incompletely developed, or almost entirely wanting.[1]

FIG. 404.

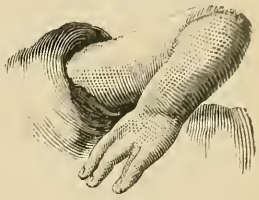

FIG. 405.

FIGS. 404 and 405.—Club-hand.

When the radius is deficient, the lower end of the ulna is enlarged to articulate with the carpus. A variety of anomalies of the muscles, vessels, and nerves may occur.

Etiology.—No satisfactory etiological cause can be assigned for the occurrence of club-hand, beyond the usual explanations urged to account for congenital deformities in general.

Symptoms.—In looking at the palmar varieties of club-hand it is seen that the wrist is sharply flexed, and that perhaps the lower end of the

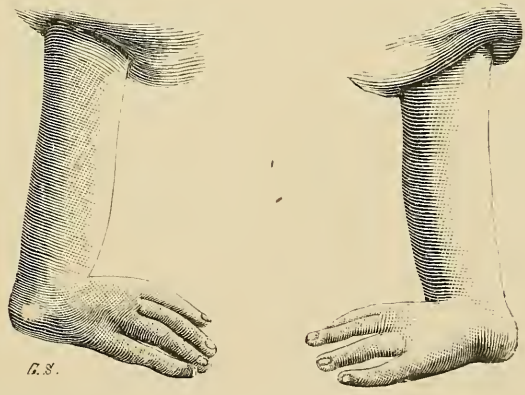

FIG. 406.—Club-hand.

radius may be covered by the skin and traversed by the extensor tendons, while the carpus articulates with the under surface of the radius. The forearm is wasted, and if the radius is absent it appears to be very

[1] Bouvier: "Dict. Encycl. des Sc. Méd.," art. Main.

slender indeed. The hand possesses a certain degree of mobility at the wrist, and when it is partly replaced the flexor tendons can be felt to be rendered tense, and stand out under the skin.

The *diagnosis* is evident, and any pathological process which is accompanied by this malposition is classified as club-hand.

Treatment.—In the worst cases, in which there is much bony deficiency, the choice lies between amputation and doing nothing. The former measure is not generally advisable, because, however malformed the hand may be, the patient finds a way to make the deformed hand of use, even though the distortion is unsightly. Osteotomy of the bone may be done if it is curved.[1]

In milder cases tenotomy of the resistant muscles or stretching the contraction by manipulation or apparatus may be efficacious. In general the decision will be made according to the severity of the case.

If treatment is begun in early life, it is generally possible to correct the deformity by bandaging the hand to splints, or by the application of a series of plaster-of-Paris bandages.

Tenotomy is not advisable if milder measures are likely to prove successful, as any possible impairment of the movements of the hand is to be avoided, and tenotomy of the extensors and flexors of the fingers has, in a few instances, led to loss of mobility from non-union of the tendons.

The hand may be immediately rectified after tenotomy or left in its former position and put into proper place only after several days.

With proper care, the results of treatment are generally satisfactory in cases in which the bony malformation is not excessive.

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[1] R. H. Sayre: Orth. Trans., vol. vi., p. 211 (with bibliography); *ibid.*, vol. ix., p. 164.

CHAPTER XII.

CONGENITAL DISLOCATIONS.

Frequency and occurrence.—Etiology.—Pathology.—Symptoms.—Diagnosis.—Differential diagnosis.—Prognosis.—Treatment.—Congenital dislocations of other joints than the hip.

Congenital dislocations, with the exception of dislocations of the hip, occur so rarely that they are of interest chiefly as surgical curiosities. The very great preponderance of hip dislocations among these has never been satisfactorily explained, and so few cases of congenital dislocations of other joints have been reported that the etiology of the affection is obscure, except for the light afforded by the study and analysis of the hip dislocations. There is one point of difference in the occurrence of congenital dislocation of the hip and of the other joints. Dislocations of the hip occur most often in otherwise healthy and normally formed children, while dislocations of the other joints are commonly associated with other malformations, such as acrania, anencephalia, spina bifida, and the like.

Congenital dislocation of the hip is neither a common affection nor one of very great rarity. Among 7,900 cases of surgical disease in children, applying at the out-patient department of the Children's Hospital, there were 39 cases of congenital dislocation of one or both hips. Chaussier,[1] in 23,293 infants born at the Maternité, found only 1 case of congenital luxation. But it is probable that it occurs in reality much oftener than it is recognized clinically. Parise[2] dissected the hip-joints of all children dying while he was interne at the Hôpital des Enfants trouvés, and in 332 he found congenital dislocation of one or both hips in 3.[3]

The distribution of the affection between the sexes and in one or both joints can be seen from the following tabulation of collected cases:

	Number.	Boys.	Girls.	Single		Double.
				Right.	Left.	
Drachmann	77	10	67	24	24	29
Pravaz	107	11	96	27	29	51
Krönlein	90	14	76	32	22	31
N. Y. Orth. Hosp. and Disp.	25	2	23	5	10	5
Boston Children's Hospital	24	0	24	7	11	6
Prahl	18	3	15	0	0	0
	341	40	301	95	96	122

[1] Chaussier, quoted by Krönlein: Deutsch. Chir., Lief. 26, p. 83.

[2] Parise: Bull. de la Soc. de Chir., 1866, vol. vii., p. 331.

[3] Prahl: Inaug. Diss., Breslau; abst. Cent. f. Chir., 1881, p. 57.

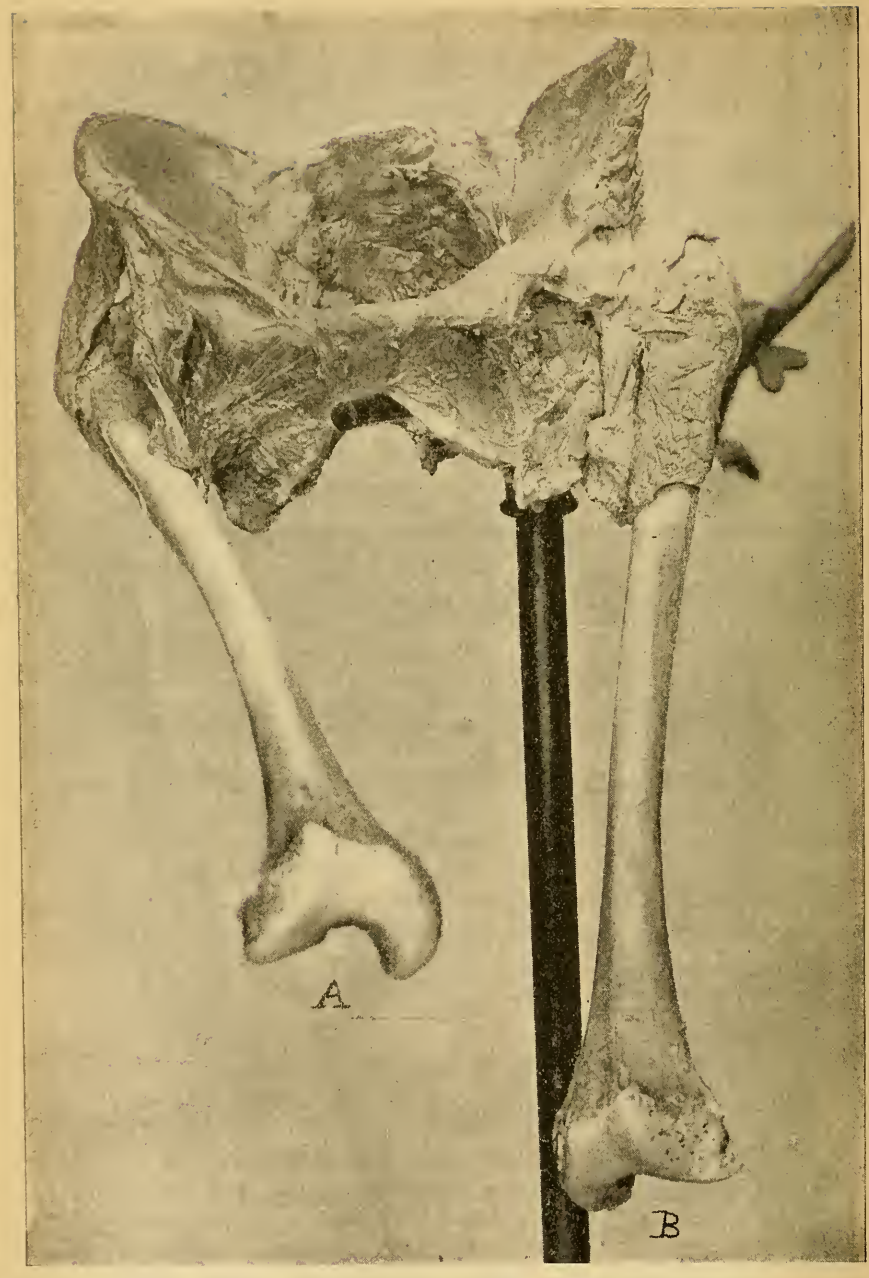

FIG. 407.—Specimen of Double Congenital Dislocation of the Hip after Removal of the Soft Parts. *A*, Femur not operated upon; *B*, operated upon with improvement in position, but still not in normal position.

The affection is much more common in girls than in boys, 301 of these 341 cases (88 per cent) having been observed in females. No etiological reason worth repeating has ever been advanced to account for this preponderance in girls except the assertion of Dupuytren, that females are more liable to malformation than males.

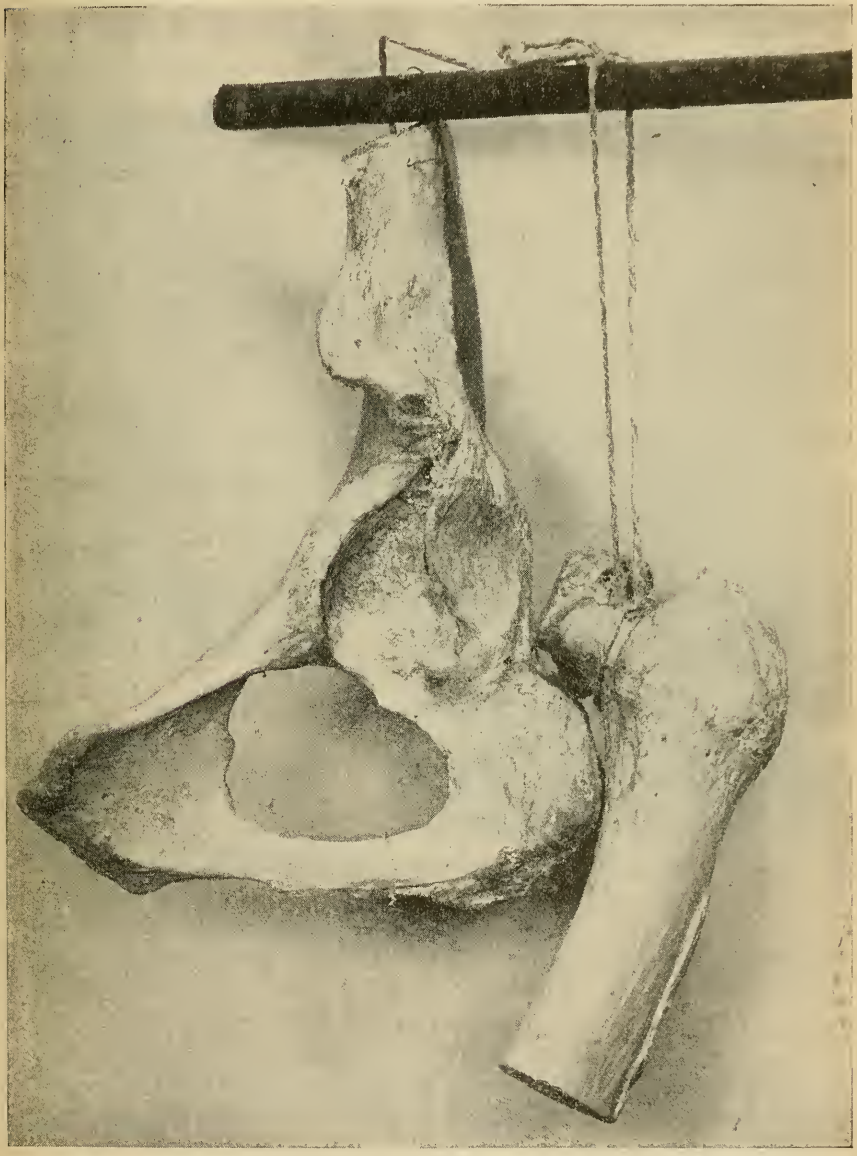

FIG. 408.—View of Innominate Bone and Head of Femur from a Case of Congenital Dislocation of the Hip, after an Operation for Formation of New Acetabulum and Reduction.

Etiology.

The affection has been known for so long a time that practically numberless theories have been advanced to account for the deformity.

The etiology of the affection is not known. True congenital dislocation without doubt is an affection of uterine life. It would seem also that it is not an arrest of development like harelip, but like congenital club-foot rather a perversion of it, a malposition of bones with the resulting structural changes of the soft parts. Violence at birth alone is not considered a cause of true congenital dislocation. The theory that the deformity is due to intra-uterine pressure at a period of fœtal development is held by many.[1]

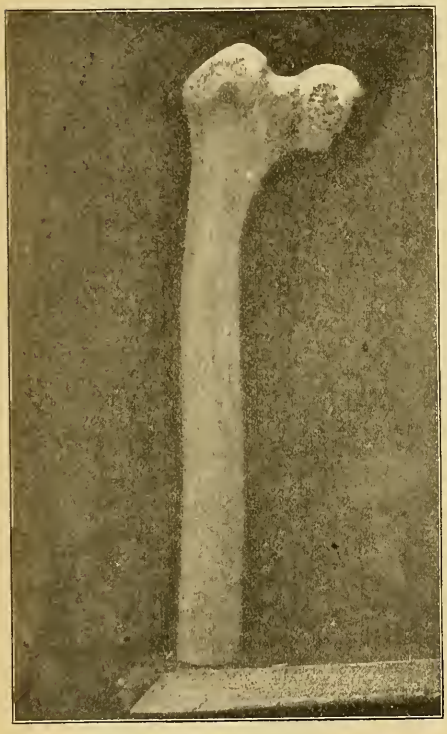

Fig. 409.—Femur in Congenital Dislocation, Showing Alteration in Angle of Neck.

But this theory does not explain the fact that the affection is much more frequent among girls than among boys. The lack of complete development in the acetabulum described by many writers will be found after thorough examination of pathological specimens to be explained by the malposition of the parts during a portion of the period of fœtal life rather than by a structural arrest of development.[2]

There is, undoubtedly, a tendency to heredity in congenital hip dislocation. Dupuytren[3] relates the case of three families in

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[1] A specimen was described by Mr. Jackson Clark in which in uterine life the thighs were flexed for so long a period without extension as to cause firm contraction of the anterior portion of the capsule. Later extension of the limb, possibly from an increase of the amniotic fluid or from any cause, would, in a shallow acetabulum, cause dislocation of the hip (Brit. Ortho. Trans., vol. i.).

[2] Path. Soc. Trans., vol. xxxviii., 308.

[3] Dupuyten: "Leçons orales de Clin. Chir.," Paris, 1832, tome iii., art. viii.

which the affection was present in several members, and cases are related by Bouvier,[1] Verneuil,[2] Stadfeldt, Caswell, and Volkmann.[3]

Pathology.

The changes in the anatomical structures seen in congenital dislocation are found in the capsule, in the muscles, and in the bones. The changes in the capsule are such as would naturally follow a uterine dis-

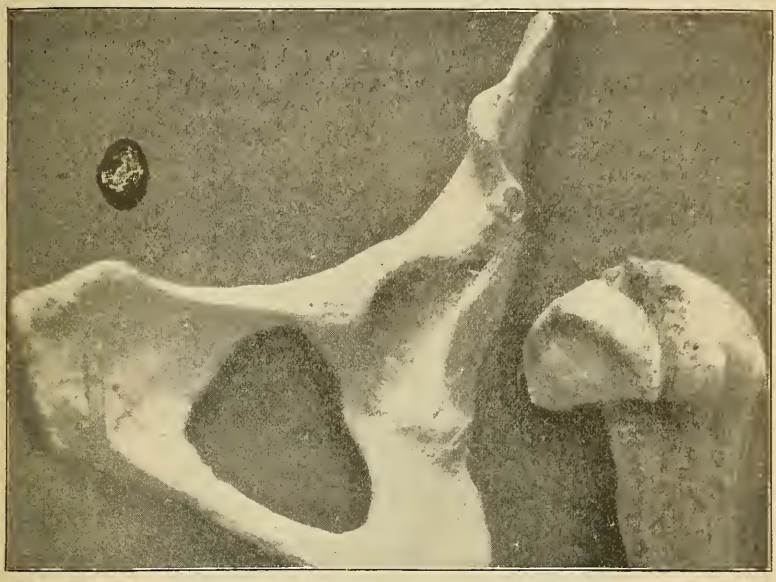

Fig. 410.—Old Congenital Dislocation of Hip with Alteration of Neck of Femur to Shape of Acetabulum. (Warren Museum.)

location before the joint structures were formed. Normally, the capsule passes from the rim of the acetabulum to the neck of the femur, the head being placed well in the socket. In congenital dislocation, when the head lies out of the socket and above the acetabulum, the capsule is stretched. Furthermore, the weight of the body, as soon as the individual walks, rests not on the head of the femur placed under the acetabulum, but falls upon the capsule, which stretches like a strap from the acetabulum to the trochanter, and this capsule necessarily becomes thick-

[1] Bouvier: "Leç. Clin. sur les mal. chron. de l'app. locomoteur."

[2] Verneuil: Gaz. des Hôp., 1866, 68, 76.

[3] Volkmann: "Krankheiten der Bewegungsorgane;" Stimson: "Dislocations," Phila., 1888, p. 103; Holmes-Coote, Adams: "Todd's Encyc.," vol. ii.; Breschet: London Med. and Surg. Journal, 1835; Journ. Edin. Phys. Soc., 1855; Bouvier: Arch. Gén. de Méd., Paris, xiv., p. 439; Bradford: Orth. Trans., vol. xii.

ened. As it is stretched across the acetabulum it becomes adherent at the rim and to a portion of the ilium, so that the acetabulum seems obliterated, being covered by thick, strong, fibrous tissue, reaching from

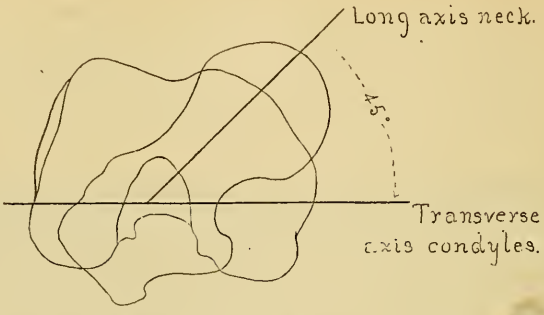

FIG. 411.—Twist of Neck in Congenitally Dislocated Femur, Looking from Above Downward.

rim to rim. This portion of the capsule is entirely shut off by adhesion from that which surrounds the head save for a small opening at the upper portion of the rim. This opening may be, and usually is, smaller

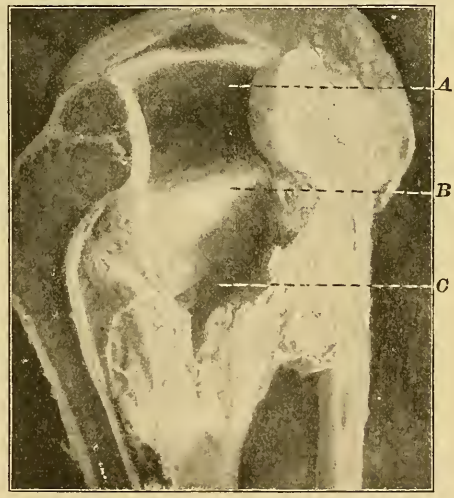

FIG. 412.—Specimen of Congenital Dislocation of Hip. *A*, Capsule stretched around distorted head; *B*, portion of contracted capsule; *C*, capsule leading to acetabulum.

than the head, and not easily stretched, as the tissues lose their elasticity from the fibrous bands, which form from the use of the capsule as a weight-bearing structure.

The muscles are changed in consequence of the changed position of the head. Some of the muscles are shortened, others are lengthened. The muscles which are shortened are chiefly the adductor group, the

psoas and iliacus, and the muscles reaching from the tuberosity of the ischium to the leg, *i.e.*, the ham-string muscles. The glutæi muscles are not shortened, and the group of muscles which pass from the pelvis to the greater trochanter, the obturators, gemelli, etc., are lengthened.

FIG. 413.—Double Congenital Dislocation of the Hip. Death from whooping-cough three months after operation. Left hip reduced; open incision; right relapsed after apparent reduction; forcible correction; narrow capsular constriction.

The capsular and peri-articular ligaments adapt themselves to the position of the deformity, and those which are attached to the lesser trochanter are particularly strong and firm to prevent the pushing of the head upward, when weight falls upon the leg. It is these tissues which oppose any attempt at reduction, and unless they are stretched or divided the deformity cannot be corrected. The alteration in the bone consists

of a flattening or alteration of the shape of the head, a twist of the neck, the consequence of malposition of the head, and in the shape of the acetabulum, which is sometimes triangular in shape and shallow.

There are three varieties of congenital dislocation, classified according to the position of the head. They may be classed as backward, upward, and forward. In the backward variety the head lies upon the dorsum of the ilium, resembling the position of the usual traumatic dislocation. In the upward dislocation the head rests above the acetabulum, and in the forward the head lies close to the anterior spine.

If the point of suspension is directly over the proper place for the acetabulum, the patient's pelvis is hung in a comparatively normal plane, but if much behind it the pelvis is tilted and severe lordosis results, the latter being the more common condition.[1]

Hung in this way, the pelvis develops abnormally, the crests of the ilia approach each other, the tuberosities of the ischia become farther apart, the whole centre of the bone is carried upward and backward, and the lateral surfaces thus tend to become vertical.

Symptoms.

The deformity usually attracts no attention until the child learns to walk at the age of two or even three years. Then it is noticed to stand ordinarily with its back very much arched and to waddle most markedly when walking is well begun. This waddle is characteristic and very marked. When the dislocation is only unilateral, the waddle becomes an exaggerated limp; in stepping on that leg the child suddenly lurches violently to the affected side, and the leg seems to have grown suddenly shorter, the child recovers itself at once and goes on with this sudden giving way whenever the affected leg is stepped upon. In double dislocation, in young children, the prominence of the trochanters is not marked enough to attract attention; in older persons, however, the prominence of the trochanters and buttocks is most noticeable. There is no complaint of pain as a rule, although people with such deformities are particularly subject to sprains and wrenches of their imperfect joints. They tire more easily than other children, although often their endurance is wonderful when one considers how serious is their mechanical disability.

Diagnosis.

The diagnosis rests chiefly on one point, the position of the trochanters above Nélaton's line, which is drawn from the anterior superior spine

[1] Holmes-Coote: Lancet, 1860; N. Y. Journ. of Med., 1848; Carnochan, Berend: Brit. Med. Journ., 1861; Canton: London Med. Gaz., xli.; Birnbaum: Wien. med. Presse, 1859; Bouvier: Bull. de l'Acad. de Méd., 183, 189.

of the ilium to the tuberosity of the ischium. In small children it is often a difficult point to determine whether the trochanter is on the line or very slightly above it. The displacement of the trochanter upward varies from half an inch to one or two inches, according to the severity of the case.

As the child lies on its back, the perineum is noticed to be unusually broad, the legs will perhaps be everted, perhaps in normal position, and

FIG. 414.—Double Congenital Dislocation of the Hip. (Fiske Prize Fund Essay.)

FIG. 415.—Lordosis and Prominence of Trochanters in Congenital Dislocation of the Hip. (J. S. Stone.)

on manipulating them they will be found to be unusually movable, especially in the direction of eversion. A click more or less marked will ordinarily be felt as the head of the bone glides over a band of fascia or the rudimentary acetabulum, but a similar click is sometimes felt in children with normal hip-joints.

On pulling the leg with gentle force the trochanter will be felt to

come down, if the other hand is placed upon it, and to slip back when the leg is released, and a measurement will show that the leg has actually been lengthened temporarily. This movement is most marked when the thigh is flexed and traction is made at a right angle to the axis of the body.

The muscles are in good condition and the children ordinarily very healthy ones. In unilateral dislocation, the leg of the affected side is slightly smaller than the other.

The diagnosis must not be made on the simple shortening of one leg. That is so common an occurrence in children otherwise normal that it is of slight importance unless there is the additional sign of a trochanter above Nélaton's line.

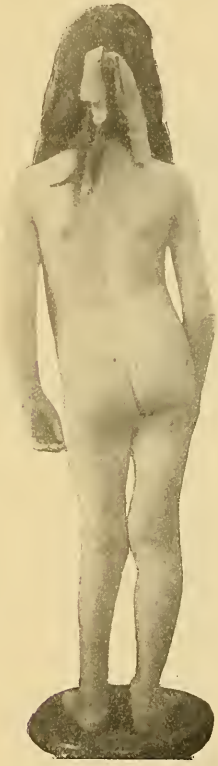

FIG. 416.—Unilateral Dislocation of the Hip. (Fiske Prize Fund Essay.)

FIG. 417.—Prominence of Trochanters in Double Congenital Dislocation of the Hip. (Fiske Prize Fund Essay.)

In larger children and adults, the conformation and outline of the hips are so distinctive that the diagnosis may be made almost at a glance; but in young children this is not the case.

Trendelenburg has called attention to an important diagnostic symptom. When a normal child stands upon either limb and flexes the other at the knee and thigh, the line of the fold of the buttock will be seen to be

kept on a level. In the case of congenital dislocation of the hip, however, the opposite buttock and that of the limb on which the patient stands will be seen to drop if the patient takes this attitude. This is to be explained by the fact that in congenital dislocation of the hip, owing to the fact that the head of the femur is not in the socket, the muscles

FIG. 418.—Lordosis in Double Congenital Dislocation of the Hip. (Fiske Prize Fund Essay.)

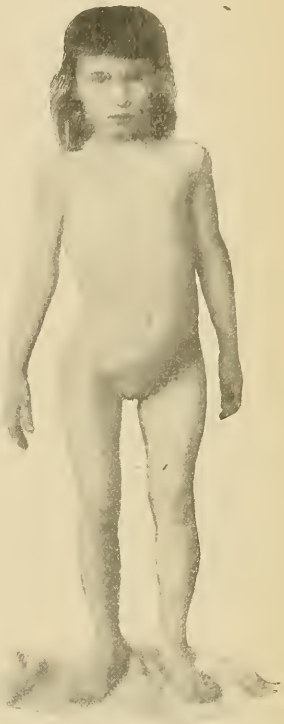

FIG. 419.—Broadening of Perineum in Double Congenital Dislocation of the Hip. (Fiske Prize Fund Essay.)

from the great trochanter and the pelvis (which serve to keep the pelvis when supported on one side level) have no purchase and are therefore inefficient.

DIFFERENTIAL DIAGNOSIS.

The following affections may be confounded with congenital dislocation of the hip in smaller children: coxa vara, distortion following infantile paralysis, separation of the epiphysis, deformity following early arthritis of infancy, traumatic dislocations, and the deformities of hip disease.

In all these affections, with the exception of the first, viz., coxa vara,

there should be a history of previous injury or illness; and in all, with the exception of coxa vara and infantile paralysis, the freedom of motion of the femur seen in early congenital dislocation is not found.

Coxa vara, or the rhachitic distortion of the neck of the femur, which shortens the limb and raises the trochanter above Nélaton's line, may be confounded with congenital dislocation.

The mistake can be avoided if the fact is borne in mind that in coxa vara the head is in its normal socket, while in congenital dislocation the head is to be felt outside of the acetabulum.

Coxa vara is rarely seen before five years of age, and is only very exceptionally noticed as early as three.

In small children with fat buttocks it is sometimes difficult to find with certainty the dislocated head. The diagnosis is aided by remembering that when the head of the femur is in the acetabulum, rotation takes place with the acetabulum as the centre, and the neck as the radius of the arc of motion; when the head is out of the acetabulum, the trochanter is the centre of motion, and the looser head describes the arc.

The affection of congenital dislocation is occasionally regarded as a disease of the spine, as marked lordosis is always present, and in many instances spinal corsets have been applied with the idea that this is the chief source of the trouble.

A skiagraphic picture is of great value in diagnosis, and if accurate is conclusive. In young children, owing to the large amount of cartilage in the epiphysis (translucent to an *x*-ray), radiographs are not always so definite as is desirable.

Prognosis.

The disability caused by this affection in childhood is slight. The limp is noticeable, and, in double congenital dislocation, may be distressing. As the patient becomes older and the weight increases, some annoyance may be caused in adolescence; but the disability ordinarily is not great until middle life or old age. In single dislocation the disability in adults may be only a disability to engage in active occupation, accompanied by occasional attacks of severe muscular pain, with muscular cramps. These attacks subside under rest, but if the patient becomes heavier or feeble, they may necessitate the use of crutches and cause severe disability. When the dislocation is on the dorsum the disability is greater than when it is anterior or above the acetabulum. Muscular patients suffer less than those with feeble muscles. In double dislocation the disability is increased.

No new acetabulum of any practical importance forms in most of the cases, and with the body suspended from the femurs by a loose capsular ligament, the patient goes through life walking with the greatest discom-

fort and effort at each step, always preserving that most characteristic swaying from side to side.

If so uncertain a matter can be formulated, it may be said that in general the tendency of these cases when untreated is to remain stationary or to grow somewhat worse. The pelvis, although altered in shape, does not appear to be changed in such a way as to interfere with childbirth.

The prognosis in cases which are treated will be considered under that head.

Treatment.

Treatment by Extension and Apparatus.—When one considers the problem to be solved in the treatment of congenital dislocation of the hip, it is easy to see why the remedial means proposed are, in general, so inefficient.

The methods for treatment of congenital dislocation of the hip are: (1) by apparatus; (2) by operative *reduction;* (3) by forcible reduction without incision.

The treatment by apparatus, consisting of the application of corsets pressing upon the trochanters to check the increase of the sinking of the pelvis between the hips and the lordosis, is certainly palliative rather than curative. The same may be said of treatment by traction appliances and ischiatic supports.

The treatment by traction recommended by Guérin, Pravaz, Carnochan, and more recently in a much more complete form by Buckminster Brown, cannot be regarded as reliable or generally practicable, as relapses eventually occur after apparent cure.[1]

The methods of treatment by operation which have been suggested are numerous; that of reduction after subcutaneous tenotomy of the muscles, from the evidence shown by dissection and pathological specimens, is manifestly inadequate if the object is to obtain a complete reduction of the dislocated hip.

Treatment by excision practised by Rose, Huesner, and Margary hardly recommends itself as justifiable, unless in painful or helpless cases of single dislocation; but in double congenital dislocation it would seem of doubtful advantage.

Operative Reduction.—To Hoffa belongs the credit of having first presented to the profession an operative method of value. This has been modified by Lorenz and himself and may be described as follows:

The patient is to be placed upon the back with the limb slightly abducted and rotated outward. The incision is made in a line drawn from in front of the anterior superior spine, obliquely downward and back-

[1] Bull. de l'Acad. de Méd., Paris, vol. iii., p. 408; Bull. de la Soc. de Chir., 1864, 218; Boston Med. and Surg. Jour., June 4th, 1885.

FIG. 420.—Congenital Dislocation Reduced.

ward, crossing the femur a short distance below the top of the trochanter. The incision should be along the outer edge of the tensor vaginæ femoris, between this and the anterior border of the glutæus medius. The incision should pass well below the top of the femur, and should cross it slightly above the level of the trochanter minor. The tensor vaginæ femoris is retracted and the fascia lata divided by a straight incision, and, if necessary, by an additional cross incision. The glutæus is also retracted, and beneath the tensor muscle the rectus femoris will be found, with a reflected tendon passing outward, to be attached to the ilium above the acetabulum. If the muscular tissues are well retracted the capsule will be uncovered and can be split. This should be done by an incision in the direction of the original skin incision, and should be free enough to expose the whole head and neck as far as the trochanteric line, and, if necessary, a cross incision is made. An assistant should flex the thigh to a right angle to the trunk, and the attachments of the capsule to the neck and the trochanteric line, including the lesser trochanter, should be thoroughly freed both on the anterior and posterior surface of the neck to such an extent that the surgeon can pass his finger completely around the neck. The head can then be thrown out, the ligamentum teres having been divided, if present. The head of the femur can be then pulled aside and a clear view of the capsule covering the acetabulum, as well as the acetabulum, can be had. If the capsule is constricted above the acetabulum it can be cut with a herniotome or stretched with a dilator, or enlarged with a curette. It is important that the bony edge overhanging the acetabulum should project sufficiently to furnish a firm socket after the head is reduced. It is sometimes difficult, if the tissues are imperfectly divided, to find the socket for the reason that a portion of the capsule lies flat across the socket and is adherent to the edges, the surgeon feeling only the upper edge and a mass of connective tissue; but when this difficulty is met it is necessary to enlarge the incision, as it is essential that the head be placed well in the socket. A curette to enlarge the acetabulum may be needed.

It is sometimes necessary, if the head of the femur is conical in shape, to remove a portion; but if the cartilage on the acetabulum is removed and the head of the femur freed from its cartilage, ankylosis is liable to result. It is particularly necessary that the capsule should not be folded in attempted reduction in such a way as to prevent the free entrance of the head into the acetabulum, and it is especially important that the connection between the acetabulum and the femur at the trochanteric line and lesser trochanter should not be so firm as to prevent the easy reduction of the head into the socket. When it is found that the head when reduced into the socket will not remain there if the leg is adducted or extended, some remaining fibres of the capsular attachments on the anterior surface, passing from the ilium to the lesser trochanter and

its adjacent parts, will be found to exist. After the acetabulum has been deepened sufficiently, the reduction of the dislocation should be performed.

After the reduction the redundant capsule can be stitched, with free drainage, or packed, according to the judgment of the surgeon as to need

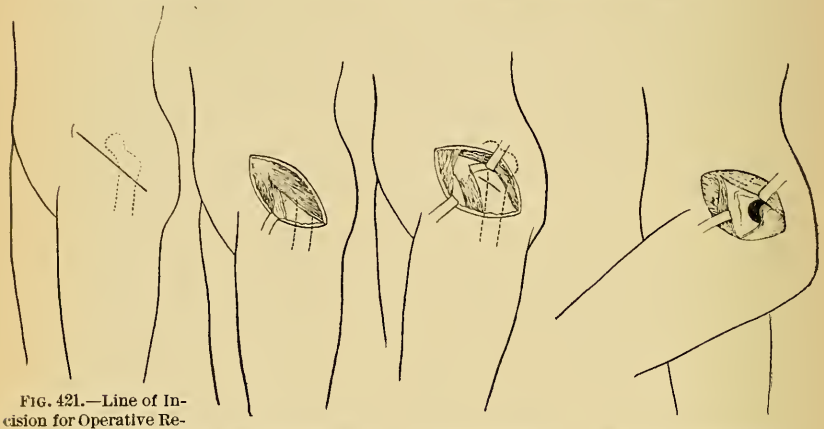

FIG. 421.—Line of Incision for Operative Reduction. FIG. 422.—Second Step. FIG. 423.—Third Step. FIG. 424.—Fourth Step.

of complete drainage, or as to trust in healing and absorption. Drainage is of especial importance, as the cavity is a deep one and may be shut off in the process of repair by muscular contraction. Furthermore, in this region the danger of infection from urine, in some small children, is

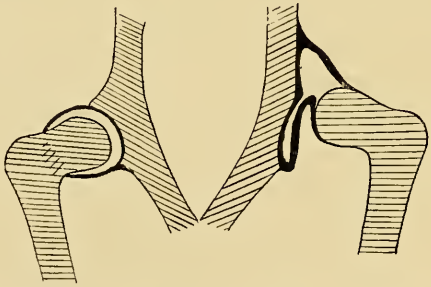

FIG. 425.—Diagram of Section of Capsule in Normal and in Congenitally Dislocated Hip.

great. The cases of death from sepsis are apparently due to omission of this precaution. The limb should be flexed by means of a plaster-of-Paris spica reaching from the thorax down to the foot, holding the limb in a strongly abducted position. The position of the limb can be gradually brought to normal by later application of plaster-of-Paris bandages.

Forcible Reposition.—This method, presented by Paci and greatly improved by Lorenz, has been employed with undoubted and permanent success and with much less risk than that following reduction by incision.

The operation is applicable in children younger than five and in some cases in children as old as seven. Lorenz has reported success in even older children.

Before the operation, as a preparatory measure, traction to stretch the muscles can be employed, combined with gradually increasing abduction.

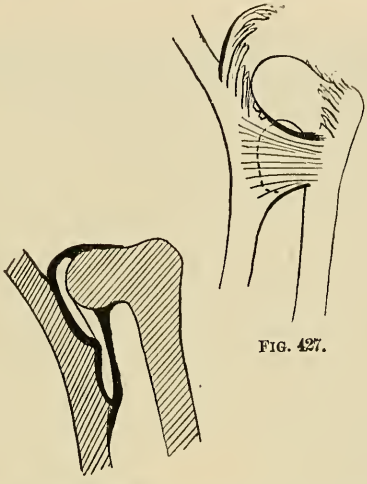

FIG. 427.

FIG. 426.

FIGS. 426 and 427.—Diagram Showing Difficulties in Reduction. 1, In the capsule covering the acetabulum; 2, in the shortened capsule between the acetabular rim and the lesser trochanter.

After a short time of this preliminary treatment the patient should be anæsthetized and extreme force applied to the limb, with the thigh ab-

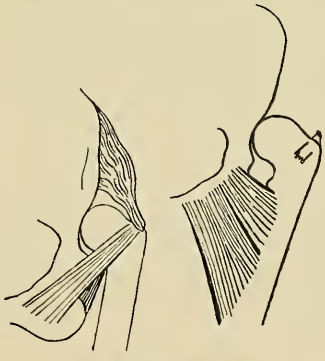

FIG. 428. FIG. 429.

FIGS. 428 and 429.—Diagram Showing Pelvi-trochanteric and Pelvic Muscles in Congenital Dislocation of Hip.

ducted. Traction is exerted by means of a loop of yarn placed around the ankle and attached to a screw force fastened to the end of the table. Counter-traction is exerted by means of a long sheet placed beneath the

perineum on the unaffected side or by means of perineal resistance. Force is slowly applied and as the pelvis tilts abduction is developed. This stretches the adductors, the flexors, the hamstrings, the rectus femoris, and the capsule, the shortened condition of which holds the

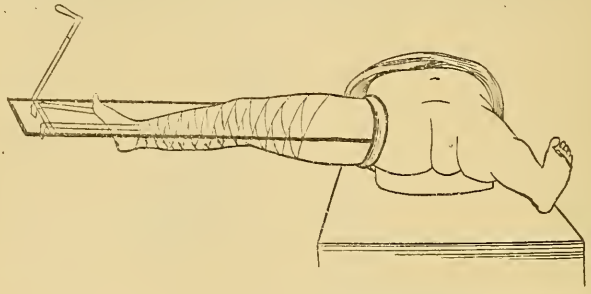

FIG. 430.—Apparatus for Traction in Abducted Position.

femur in place. After this procedure has been carried on for several minutes, accompanied by forcible manual stretching, by massage of the adductor group, aided possibly by a tenotomy, the different manœuvres to stretch pericapsular ligaments of the hip should be executed. The reduction takes place with a noticeable jerk as the head of the femur

FIG. 431.—Double Congenital Dislocation Unreduced.

passes into the acetabulum. If dislocation recurs when the leg is adducted and extended it indicates that the anterior and inner attachments of the muscles, ligaments, and capsule are not stretched, redislocation takes place if the limb is brought to a straight position from an abducted one, and further stretching is necessary. After the reduction is thor-

oughly assured the limb should be placed in a plaster-of-Paris spica in a strongly abducted position.

It will be found that the chief obstacle to reduction is in the contraction on the inner side of the joint, especially in the adductors and the pericapsular ligaments which connect the upper part of the acetabulum with

FIG. 432.—Congenital Dislocation. Reduction by incision. Osteotomy of shaft to correct twist of neck.

the lesser trochanter. It is therefore necessary that the limb should be put up in an abducted position and kept in this position until healing has been secured.

When a twist in the neck of the femur has been developed by its abnormal position from the congenital malposition, the limb may need to be inverted after reduction in order to maintain during healing the proper relation of the head to the acetabulum. When this twist of the neck is marked, a subsequent linear osteotomy of the shaft of the femur and correction of the twist are necessary to establish the proper position of the corrected limb in walking.

The after-treatment needs to be conducted with care to prevent re-

lapse. This is liable to occur if the head of the femur has not been thoroughly placed under the acetabulum, if the acetabulum has not a sufficiently projecting upper edge and has not been sufficiently deepened, or if the redundant portion of the capsule has been folded in during the reduction between the head and the acetabulum, or, if a marked twist of the neck exists, a relapse may take place in locomotion unless the twist is corrected by growth or operation.

The most efficient method of after-treatment consists of fixation of the limb in a position in which relapse is impossible until the ligaments and muscles have adapted themselves so as to retain the head in the corrected position. This position is one of strong abduction which is gradually brought to the normal position. Walking on the limb so far as it is practicable is permissible with the limb in an abducted position, and the later plaster-of-Paris bandages need not include the foot.

When redislocation occurs walking will be improved provided the posterior dislocation can be made into an anterior one.

The after-treatment necessarily involves time, six months' fixation being usually necessary.

The question of absolute ultimate benefit from the operation is not easily determined, as the final result is somewhat dependent upon the child's growth. As a rule, some time is needed before the improvement in the child's gait after operation is marked.

Generally, children and adolescents suffer little from the deformity if single, but the annoyances that follow in old age justify thorough measures of correction in youth.

It is manifest that when the reduction of the head is secured it is better for the usefulness of the limb and the growth of the trunk than when dislocation remains.

Congenital Dislocations of Other Joints than the Hip.

It will be necessary to mention only the most frequent varieties of congenital dislocations of other joints than the hip.

Shoulder-Joint.—These dislocations may be divided into two classes: those in which the glenoid cavity is absent or imperfectly developed, and those in which it is approximately normal. In the latter class the position of the head of the humerus is usually subspinous. Shoulder-joint dislocations of this class present three distinct forms: (1) those due to irregular development of the joint; (2) those in which the bones are normally formed and in which the displacement may have occurred during delivery; and (3) those also with normal bones in which the displacement is the result of paralysis antedating birth, or caused during delivery.

Dislocations of the Shoulder Apparently Congenital.—The lesion is

sometimes double or associated with other congenital affections, and in one case two children in one family were similarly affected.

In a case of the first class described by Smith there was hardly a trace of the normal glenoid cavity.

In the class of cases in which the glenoid cavity is approximately normal the origin is, of course, less certainly congenital. The position of the head of the humerus in these cases seems usually to be subspinous. The limitation of function is similar to that in traumatic dislocations. Eve and Phelps have operated on such cases with good functional result. J. S. Stone operated on a case in which the glenoid cavity was found to be normal, and improvement in the usefulness of the arm followed. Lewis reduced a case without incision in which the reduction was permanent, as did also Jenni. In this class of cases it would seem, especially after

FIG. 433.—Congenital Dislocation of the Knee. (Genu recurvatum with club-foot.)

complicated labor, that a subspinous dislocation of this type was likely to be improved or cured by reduction or operation. When the subcoracoid or subacromial luxation is due to faulty development of the glenoid cavity the outlook is not so encouraging. Separation of the epiphysis of the humerus occurring during delivery may simulate congenital dislocation of the shoulder.

Elbow-Joint.—Dislocations of the elbow are of little practical surgical interest, the reported cases being for the most part curiosities and not following any one type. There are four varieties:

1. Dislocations backward of the head of the radius, with or without abnormality of the radius and ulna in the upper third of the forearm.

2. Forward and upward dislocations of the radius.

3. Backward dislocation of the radius and partial dislocation of the ulna with imperfect development of the external condyle.

4. Dislocations of both bones backward.

Wrist.—Congenital dislocations of the wrist are for the most part associated with bony deformity and are classed with club-hand.

Knee.—Congenital dislocation of the knee is rare; but 24 cases are

reported by Phocas, in addition to which it has been possible to collect 25 others. In Taylor's list of 34 cases, in 18 the deformity was bilateral, in 16 unilateral; in 24 of the 34 the displacement was anterior.

There are two principal forms of congenital dislocations of the knee, one in which the tibia is dislocated upward on the femur and the other in which the leg is hyperextended as a result of the forward dislocation of the tibia on to the anterior surface of the condyles of the femur.

Lateral subluxation occurs rarely and in cases with other congenital affections. The commonest dislocation is the forward one known as genu recurvatum which is found associated with breech presentation. The condyles of the femur can be felt at the back of the popliteal space, and the patella is often small, occasionally absent. Lateral mobility is the exception, and, as a rule, is confined to the bilateral cases when other deformities coexist. A case of ankylosis with anterior luxation of both tibiæ has been reported by Krönlein. Modifications in the shape of the bones, ligaments, and cartilages of the knee-joint have been recorded in these cases.

The forward dislocation of the knee is generally to be corrected by manipulation and the application of splints to the leg in a corrected position. Following these measures, apparatus should be applied to limit the lateral motion if present and to decrease the amount of hyperextension and increase the amount of flexion. Apparatus must be worn, of course, till the structures about the joints have adapted themselves to the new conditions.

Posterior dislocation of the knee has been reduced by tenotomy, as has been done in a case of Hamilton and by Sayre. Massage, manipulation, with or without an anæsthetic, or even osteoclasis, followed by the use of retentive apparatus are to be regarded as the proper methods of treatment.

Dislocations of the patella, described as congenital, although their congenital origin is doubted by some writers, are as follows:

Displacements upward with lengthening of the patellar tendon.

Dislocations outward with absence or flattening of the outer condyle of the femur.

Dislocations outward with approximately normal condyles.

In a case of outward dislocation in a child ten years old, apparently congenital in origin, operated upon by one of the writers, the dislocation was reduced by a long vertical incision at the outer side of the patella and a reefing of the capsule at the inner side.

Ankle.—Inward and outward dislocations of the ankle are recorded in cases in which there was bony defect of the tibia or fibula.

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CHAPTER XIII.

INFANTILE SPINAL PARALYSIS.

Definition.—Etiology. — Pathology. — Symptoms. — Diagnosis.—Differential diagnosis.—Prognosis.—Treatment.

Infantile spinal paralysis is an affection which attacks chiefly children in their first dentition. It comes on with a sudden onset and deprives certain muscles and often an entire limb of muscular power, and the parts affected undergo rapid atrophy. The paralysis is a purely motor one.

The pathological name of the affection is acute anterior poliomyelitis, and other common names are: Infantile paralysis, essential paralysis of children, acute atrophic spinal paralysis, "teething palsy" or dental paralysis. Regressive paralysis (Barlow), myelitis of the anterior horns (Seguin), myogenic paralysis (Bouchut). German: Kinderlähmung, spinale Kinderlähmung, essentielle Kinderlähmung. French: Paralysie spinale, paralysie infantile, paralysie des petits enfants, paralysie essentielle de l'enfance, téphromyélite antérieure aiguë (Charcot), etc.

The disease was first mentioned by Underwood[1] in 1784, but it was not then separated clearly from the other kinds of paralysis affecting children, and it remained for Heine to give the first accurate account of the disease in 1840.

Etiology.

Little is known of the causation of infantile paralysis. The disease is usually limited to the time of the first dentition in children. Of 250 cases (collected from Heine,[2] Duchenne the younger,[3] and Barlow[4]) 154 occurred between 6 months and 2 years. Of Seeligmüller's[5] 71 cases, 90 per cent occurred before 3 years, and of 150 cases considered by Sinkler[6] six-sevenths of all cases occurred in the first 3 years. In 83 cases investigated by Schultze 11 were in the first year and 31 in the second, while 3 were over 5 years old. Once it occurred in a baby 4 weeks old.[7] Inas-

[1] "Treatise on the Diseases of Children," London, 7th ed., 1826, p. 251.

[2] Heine: "Ueber sp. Kinderlähmung," 2 Aufl., Stuttgart, 1860.

[3] Duchenne fils: Arch. gén. de Méd., tome ii., 1864.

[4] Barlow: "On Regressive Paralysis," London, 1878.

[5] Seeligmüller: Gerhardt's "Handbuch der Kinderkrankheiten," v., 1881, p. 1.

[6] Wharton Sinkler: Keating's "Encyclopedia," p. 683.

[7] Schultze: "Lehrb. der Nervenkrankheiten," Stuttgart, 1898, p. 223.

much as it is well known that children are especially irritable and liable to neuroses of all sorts during the time of dentition,[1] it is assumed that this condition of exalted nervous irritability is sufficient to render the cord most susceptible to any irritation. The disease has been seen as early in life as the twelfth day in a case of Duchenne's, and adults are not exempt from a similar affection, which is occasionally of traumatic origin.

Exposure to severe heat and sunstroke are mentioned as occasional causes of the attack of paralysis. Most cases occur during warm weather. Twenty-seven of Barlow's 53 cases occurred during July and August, and Sinkler found that in 213 out of 270 cases the disease occurred from May to September inclusive.

Exposure to cold, or chilling of the heated body, and sitting on the damp grass or on cold stones, are mentioned as occasional causes of the attacks of paralysis. Over-exertion is reported as at times the cause of the affection. The disease is also known to occur during or soon after measles,[2] scarlet fever,[3] vaccinia, and typhus and typhoid fever, pneumonia, and erysipelas.[4] An acute feverish attack, like indigestion, is often assigned as the cause, but inasmuch as it may be the chief symptom of the onset, no weight can be attached to it.

Certain other cases seem to come on after a fall, and it is quite possible that a traumatic hemorrhage into the substance of the cord might occur, causing much the same symptoms as anterior poliomyelitis,[5] but such traumatic histories are rare.

As a matter of fact, the disease attacks healthy and unhealthy children, boys and girls alike, usually without any demonstrable cause, coming on in the midst of perfect bodily health, and apparently the affection has no dependence upon a hereditary influence. It is by far the commonest paralysis in children and in most cases develops during the night rather than the day and commonly during the hot months.

Modern opinion rather inclines toward regarding the affection as infectious in origin, although the infecting organism has not been definitely demonstrated. Fresh cases have been investigated as to the presence of a microorganism with negative results for the most part. Schultze,[6] however, in a case of what he considered anterior poliomyelitis of the arms and neck in a boy of five, did a lumbar puncture on the thirteenth day and found in the cerebrospinal fluid withdrawn an organism which he de-

[1] Henry Kennedy: Dublin Quart. Journ., ix., February and May; xxii., August and November.

[2] Seeligmüller: Loc. cit.

[3] Roger: Gaz. méd., 1871.

[4] Meyer: "Die Electricität und ihre Anwendung auf pract. Medicin," Berlin, 1868, 3d ed.

[5] Taylor: Med. Times and Gazette, 1879, vol. i., p. 187; Duchenne: Arch. gén. de Méd., 1864; Kennedy: Dublin Quarterly, 1850, and Frey: Berl. klin. Woch., 1874.

[6] Münch. med. Wochenschr., 1898, No. 38, p. 1197.

scribed as the Weichselbaum-Jäger diplococcus. The later history of the case was that of infantile paralysis. As a somewhat similar form of paralysis follows certain cases of cerebrospinal meningitis, this evidence cannot be accepted as conclusive.

The affection occurs at times as an epidemic which lends force to the view of its infectious character. Such epidemics have been reported from time to time. The earliest was in 1843.[1] Medin[2] reported 44 cases occurring in Stockholm in the summer of 1887. There were three deaths, and although in general the ordinary type of infantile paralysis was followed, a few aberrant cases were seen. Briegleb[3] reported an epidemic in 1890.

The epidemic reported by Caverly[4] in Vermont, around Rutland, in the summer of 1894, was very extensive and very severe. The epidemic included 132 cases, and 18 cases were fatal. The cerebral tracts were in several cases involved. An epidemic in Australia was reported by Alston in 1897, consisting of 14 cases.[5] An epidemic in Cherryfield, Me., was reported by Madison Taylor. There were 7 cases with 1 fatality.[6] W. Pasteur[7] reported in 1896 an epidemic occurring in 7 members of the same family. A very careful investigation of an epidemic occurring in North Adams, Mass., was made by Brackett.[8] Ten cases were seen and examined which in general were of a more severe type than ordinary cases. The initial fever was high, the distribution of paralysis was on the whole more extensive. The sphincters were at times involved, and prolonged hyperæsthesia was found in the severer cases. These features seem in general to characterize the epidemic cases as described by others. At North Adams all of the cases but one occurred along the banks of the two rivers flowing through the town; no other common etiological factor could be found.

Pathology.

The study of autopsies[9] in recent cases of infantile paralysis has resulted in the opinion among recent writers that the entire gray matter of the cord is the seat of interstitial inflammation and that the changes in

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[1] Colmer: Am. Jour. Med. Sciences, 1843.

[2] Medin: Proceedings Tenth Int. Cong., vol. ii., div. iv.

[3] Briegleb: Inaug. Diss., Jena, 1890.

[4] Journ. Am. Med. Assn., January 4th, 1896.

[5] Australian Med. Gaz., April 24th, 1897.

[6] Boston Med. and Surg. Journ., cxxix., 504.

[7] Trans. Clin. Soc. of London, 1896, p. 143.

[8] Trans. Am. Orth. Assn., vol. xi., p. 132.

[9] Goldscheider: Zeit. f. klin. Med., xxiii., 1893, p. 494; Dauber: Zeit. f. Nervenheilkunde, vol. iv.; Siemerling: Arch. f. Psychiatrie, xxvi., 267 (with literature to 1894).

the ganglion cells are secondary[1] (Sachs). Goldscheider's study would make it appear that the blood-vessels are first affected and that from these the neuroglia is attacked, and that the changes in the ganglion

FIG. 434.—Poliomyelitis Anterior; Part of an Acute Myelitis. Death at eight days. Section through lumbar segment, showing disruption of anterior gray matter from hemorrhage. (Sachs.)

cells are degenerative and secondary in them as well as in the nerve fibres. The cases of Siemerling are confirmatory, and both sets lead to the view that the inflammation is interstitial and not parenchymatous.

The process may involve a few segments of the cord, or it may involve a greater part of the cord and extend to the medulla and pons. The larger ganglion cells of the anterior horns in the affected area disappear and the ones that remain are shrunken and the cell processes have disappeared. The entire gray matter of the affected side shrinks, and even the white matter is smaller than that of the other side. The columns of Clarke disappear and the anterior nerve roots become smaller than those of the other side.

Atrophic changes soon take place in the paralyzed limb. Sometimes

[1] Von Kahlden: Cent. f. Path., September 14th, 1894 (Charcot's view).

the atrophy affects the bones, which become shortened even to the extent of affecting the length of a limb by several inches. At the same time the affected limb grows comparatively smaller in circumference than that

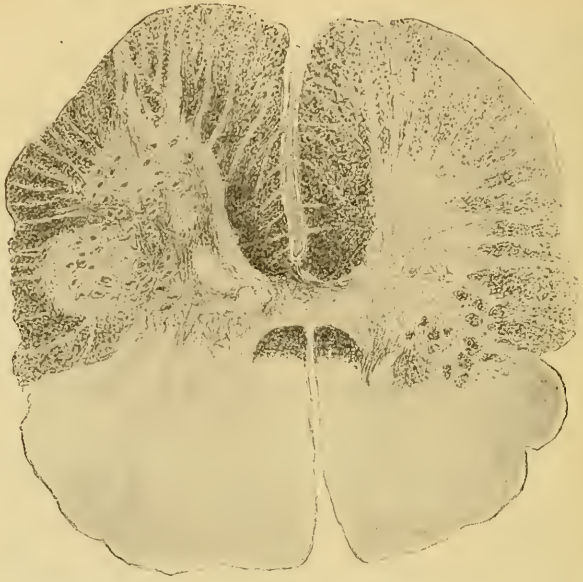

FIG. 435.—Poliomyelitis Anterior of Old Standing. Disappearance of ganglion cells on right side and shrinking of right half of cord. Cervical region. (Sachs.)

of the opposite side. This is frequently the result of retarded growth rather than of real wasting, but both factors at times enter into the

FIG. 436.—Anterior Poliomyelitis. Chronic stage; section through sixth cervical segment; diminution of anterior gray matter and of entire half of right side. (Sachs.)

change. In other instances, even in severe cases, the bones seem but little affected, while the atrophy of the muscles is very marked.

The epiphyses are stunted, and the ligaments become thin and loose, and dislocations and distortions of the joints are favored. It is in the

muscles that the most notable changes are found. These waste rapidly and become flabby to the touch; and microscopic examination shows a loss of striation followed by a granular degeneration of the fibres until little is left beyond muscle corpuscles and fat granules contained in sarcolemma. This, of course, is clearly more than the atrophy of disuse.[1]

That poliomyelitis represents an acute inflammatory condition of the anterior gray matter of the spinal cord is conceded on all sides, but the question arises, what the origin of such inflammation may be. The only satisfactory explanation at the present day is to suppose that the inflammation is the result of an acute infection which happens to be located in the spinal cord, just as other infectious diseases show a predilection for other sites in the body. The microbic origin has not yet been satisfactorily demonstrated, but all the clinical facts point toward this view, and the close dependence of the myelitic process upon the distribution of the blood-vessels lends further color to this theory.[2]

Symptoms.

In general the clinical history of the disease falls into three stages:

(*a*) The onset, to which stage belong the acute febrile symptoms and the development of paralysis.

(*b*) The stage of convalescence, which begins at the time of the full development of the paralysis, and is followed by a brief stationary period, and finally rapid and then slower improvement until a stationary period is reached.

(*c*) The stage of deformity in which wasting of the affected limb is present and static, paralytic, and contraction deformities have supervened.

No arbitrary subdivision of the classes of symptoms will be made, because in reality the stages run into each other so gradually that it seems unjustifiable to divide them so practically.

Infantile paralysis is oftenest ushered in by a mild or severe febrile attack, which presents no definite characteristics to distinguish it from any ordinary attack of cold or indigestion.[3] The elevation of temperature is not excessive, commonly from 100° to 102° F., sometimes even 104°. With this fever are apt to be associated vomiting, convulsions, giddiness or other cerebral disturbance, sometimes even delirium. Older children complain of pain in the back and limbs. There is, as a rule, no warning of the attack, although Seeligmüller has noted at times a disinclination to walk or stand as much as usual for some days preceding—a fact quite in accordance with Lange's theory that over-exertion of the muscles has much to do with the production of the disease. Convulsions may be

[1] Gowers: "Dis. of Nerv. Syst.," vol. i., 253; Jacob v. Heine: Loc. cit.

[2] Sachs: "The Nervous Diseases of Children." New York. 1895.

[3] Vogt: "Ueber die essentielle Lähmung der Kinder."

present,[1] and when they occur they are usually followed by a period of unconsciousness. The feverish attack at the onset may, however, be very severe,[2] at times lasting two or three days (or even weeks) before the paralysis appears. More commonly, however, it is very slight and scarcely noticed. In certain rare cases, two or even three[3] attacks of fever are noted, each followed by an increase in the paralysis.[4] Pain of a rheumatic character in the back and limbs is a common initial symptom.[5] In certain cases[6] all feverish and other symptoms are absent[7] at the onset, and the child is suddenly discovered to be paralyzed in one or more limbs. Such paralysis comes on oftenest in the night, but it has been observed to come on quietly in the daytime, while the child was at play.[8] In these cases there may be no succeeding illness, and the paralysis is the only symptom throughout.

Diarrhœa, vomiting, general hyperæsthesia, and much nervous irritability are other symptoms which often accompany the onset of the paralysis. During the first few days there may be paralysis of the bladder with retention or incontinence of urine, but it disappears after a few days or weeks. Pain is a symptom but little noted in infantile paralysis, but it is not uncommon, nor does it indicate of itself the presence of any additional pathological process.

The paralysis itself very quickly becomes manifest and reaches its maximum within a few hours of the attack, or within a day or two, except in rare cases. Having reached its maximum and remained stationary for a short time, improvement almost invariably begins. In rare cases improvement begins immediately after the attack, and proceeds to complete recovery. These are the cases which are spoken of as "temporary spinal paralysis." The more common course is for the paralysis to remain nearly stationary for a time varying from two to six weeks, and then to improve, at first rapidly and then more slowly, for three or four months. After six months have passed, further spontaneous improvement is unusual.

Vascular changes become very marked. The temperature of the limb is much lower than that of the other. The limb is generally bluish, with a superficial stagnation of the blood, on account of an atrophy of the

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[1] Jacobi: Pepper's "Syst. of Medicine," vol. ii.

[2] Erb: Ziemssen's "Handbuch," xi., 12; Henoch: "Vorles. über Kinderkr.," 2te Aufl., 1881.

[3] Laborde: Op. cit., p. 8.

[4] Althaus: "On Inf. Par. and some allied Diseases of the Sp. Cord," London, 1878, p. 12.

[5] Duchenne fils: Arch. gén. de Méd., 1864, 37.

[6] Laborde: "De la Paralysie de l'Enfance."

[7] Seeligmüller in Rilliet et Barthez' "Traité des Mal. de l'Enfance," vol. ii., p. 551.

[8] M. P. Jacobi: Am. Journ. of Obst., May, 1874.

blood-vessels and consequent diminution of their calibre, and when the blood is pressed out of the surface capillaries by the finger it returns slowly. On account of this vascular sluggishness ulcers may form, which are slow to heal and very painful. The limb even very early loses its normal appearance, and the flaccid undeveloped look of the foot or hand is most noticeable.

Atrophy of the affected muscles begins to be perceptible a few weeks after the onset of the paralysis, while the loss of striation in the muscular fibres can be detected with the microscope within two or three days the attack.[1] The muscles may be tender to the touch during the time that they are wasting so fast, especially in adults and older children. Muscles seriously affected are toneless and flaccid from the first, and in the late stages of wasting scarcely any volume of muscle seems left when the limb is grasped with the hand.

The paralysis is a purely motor one, and although tingling and formication may be present, sensation is very rarely affected. The reflexes are abolished in the affected limb if the implication of the extensor muscles of the thigh be enough to do away with the knee jerk of the affected side.

Sometimes after an attack the paralysis may seem to be general, but the probabilities are that after improving in general, the loss of power will eventually be localized in one limb, and that if one limb originally is paralyzed the likelihood is very great that a certain amount of power will be regained, leaving only certain groups of muscles permanently paralyzed.

Distribution.—The paralysis in its distribution is monoplegic in more than half the cases, as a consolidation of the tables of Duchenne and Seeligmüller will show.

One leg paralyzed,	74
One arm "	23
Both legs "	23
Both arms "	3
All four extremities paralyzed,	7
Hemiplegic paralysis,	3
Crossed paralysis,	3
Muscles of trunk and abdomen paralyzed,	1
	137

The great preponderance of paralysis of the lower extremities is to be noted, and the liability to paralysis increases even from the thigh to the foot, and when improvement begins in a case in which both an upper and lower extremity are paralyzed, the improvement begins first in the

[1] H. W. Berg: Wood's "Ref. Handbook," vol. v., p. 504.

arm. Commonly certain groups of muscles are attacked, and when adjacent muscles are affected they seem to be selected at random oftener than by functional or anatomical association. In the leg, the extensors and the peronei are the muscles oftenest affected. The glutei are never affected alone, but they commonly share in any extensive paralysis of the leg. In the arm the deltoid suffers oftener than any other arm muscle, either alone or in association with other muscles. The "upper-arm type" of paralysis, which Erb has described, consists of the simultaneous affection of the deltoid, supra- and infraspinatus, the biceps, and the supinators. There is also a "forearm type" described by Remak[1] in which, as in lead paralysis, the extensor muscles of the hand are paralyzed while the supinator longus is spared. The serratus magnus is sometimes affected as well as the trapezius

FIG. 437.—Paralysis of Left Arm Muscles, deltoid and serratus magnus.

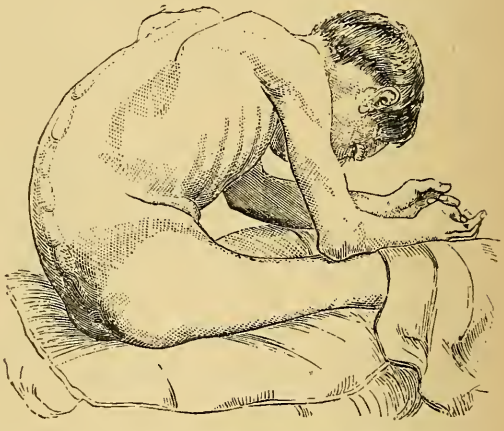

FIG. 438.—Kyphosis in Paralysis of the Back Muscles. (Gowers.)

and pectoralis major. The neck muscles are very seldom affected and the muscles supplied by the cranial nerves only rarely.

The muscles of the back may be paralyzed and the patient be unable to sit erect, or if the distribution of the paralysis is uneven lateral curvature may result—a state of affairs often made worse by allowing the patient to sit erect while the muscles are still weak. The diaphragm is occasionally paralyzed. In those rare cases of paralysis of the abdominal muscles, the patient leans back to a very marked degree, missing the restraining action of the abdominal muscles. There are, finally, cases of universal paralysis in which death soon takes place from interference with respiration.

The sequelæ of the disease are few. Progressive muscular atrophy

[1] Remak: Arch. f. Psych., Band ix., 1878–79, p. 510.

has been several times observed to start from the diseased limb, and the symptoms of lateral sclerosis at other times have been seen to develop,[1] but such occurrences are very rare.

Deformities.—The deformities which come on after infantile paralysis are late events in the history of the disease and rarely develop until at least some months after the attack. They are, as a rule, progressive in their character and the end results are often such extreme distortions that the affected limb is useless. The deformities fall into two chief classes: (1) deformities due to trophic changes, such as bone shortening, etc.; (2) deformities due to muscular paralysis.

(1) The first class is comparatively unimportant; shortening of the paralyzed arm or leg may take place with atrophy of the bone in every direction, so that a liability to fracture is of course a necessary consequence. Shortening of the arm is comparatively unimportant in itself, but shortening of the leg is likely to induce lateral curvature of the spine from the necessarily tilted position of the pelvis[2] due to the unequal length of the legs.

(2) The deformities of the second class, which are the result of muscular paralysis, are manifold and form the great bulk of the cases of deformity in anterior poliomyelitis. As a rule they do not appear earlier than two or three months after the onset and more commonly not for many months.

For clinical consideration they fall into two groups: deformities caused by contraction, and deformities due to laxity of the muscles and ligaments. Volkmann, on the ground of Hüter's investigations, explained nearly all the deformities on mechanical grounds, urging that the deformities were developed partly by reason of the weight of the limbs concerned and the position which they assumed when at rest, and partly because of the muscular insufficiency of the affected limbs which allowed the articular surfaces to be subjected to an excessive pressure when brought into use, which had the effect of gradually pressing them into abnormal position. The earlier idea had been, however, that they were brought about by the unopposed action of the muscles which were not affected. Probably both factors are active in the causation of deformity.

A word should be said in regard to the reason of the more severe affection of the anterior leg and thigh muscles than of the posterior muscles in nearly all cases. The theory has been advanced that, after a paralysis of the leg, the limb lies flaccid and nearly powerless, the toes drop, and if the sitting posture is assumed, the knees flex and the legs hang heavily down. As a result of this, the anterior muscles are always pulled upon and slightly stretched, while the posterior ones are

[1] Gowers: "Dis. of Nerv. Syst.," vol. i., p. 262.

[2] Bradford: "Etiology of Lateral Curvature," Boston Med. and Surg. Jour., 1886. cxiv.

lax. If all the muscles are equally affected, this very factor may be enough to make a great difference in the ultimate usefulness of the two groups. Stretched muscles are notoriously at a disadvantage, so far as recovery goes, in any diseased condition, and muscles at rest are much more favorably situated. So that this very point may determine in a measure the relative amount of recovery in the two groups.

Moreover, muscular contraction and consequent deformity occur only in cases in which a muscle has been allowed to remain for a long time in a shortened or stretched condition. For this reason, it is highly important to support and restrain the affected limb in a normal position (the foot at a right angle to the leg, etc.).

The common deformities from infantile paralyis which come to the orthopedic surgeon for treatment are those of the lower extremity. Considered in detail, it is best to begin with deformities at the hip-joint and then to pass on to the consideration of knee-joint deformities and distortions of the foot.

Deformities of the Leg.—Paralysis may be complete and a flail-like leg be the result, with wasted muscles, and loose distorted joints, incapable of motion or bearing weight. Such a limb is spoken of as "jambe de Polichinelle."

But more commonly the paralysis is partial rather than complete. The muscles of the thigh commonly affected are the internal and anterior groups. This constitutes a serious combination and renders walking difficult; not only is the leg abducted with a tendency to eversion, but the extensor thigh muscles cannot hold the knee rigid as is necessary in walking, the leg giving way whenever weight is put upon it. The glutei are generally implicated in this paralysis, and the contraction which is likely to result from this paralysis is flexion of the thigh alone or with abduction of the leg, a condition always associated with flexion of the knee and talipes equino-varus.

Flexion deformity at the hip produces in time a most marked lordosis in the back. When the patient stands with the leg dangling, the weight of it drags upon the pelvis and rotates it on a transverse axis, a compensation which makes it possible for the leg to hang as nearly as possible perpendicularly. This deformity is marked and troublesome.

At the knee, contraction in the flexed position (with often a tendency to subluxation of the tibia backward) is found, and in the more severe cases decided knock-knee. At other times when laxity rather than contraction predominates, hyperextension of the knee is observed and sometimes lateral mobility also exists. In severe cases of this type in which the deformity has been rectified by mechanical or operative means, the tibia lies in a plane decidedly posterior to that of the femur. The same may be said of the knock-knee which results from the greater prominence of the internal condyle of the femur. The flexion may have been

overcome, but still a decided degree of knock-knee may remain in the corrected leg.

Hyperextension of the knee may also increase to a very marked degree and is commonly associated with talipes valgus. This hyperextension results in cases in which the anterior muscles are weak and fail to hold the knee extended when walking is attempted. In these cases

FIG. 439.—Infantile Paralysis. Contractures of right leg. (Weigel.)

FIG. 440.—Standing Position of Valgus in Infantile Paralysis.

FIG. 441.—Talipes Calcaneus.

the patient throws the weight of the body upon the fully extended knee and the strain falls upon the ligaments rather than on the muscles. The posterior ligaments yield in time to this repeated weight and the patient obtains for a time a better bearing. The same deformity is favored by a tendency which these patients have to lean with the hand upon the knee when rising from a chair.

There is a tendency to outward rotation of the tibia upon the femur

in cases of long-standing paralysis of the leg. In this case the eversion of the foot in walking is a troublesome complication.

Inasmuch as paralyses of the anterior tibial muscles and the peronei are the most frequent,[1] the deformities that one sees oftenest are talipes equino-varus, or, if the peronei are intact, talipes equinus. Pure talipes varus from this cause is not common.

It will be seen that hyperextension of the knee is favored in cases in which talipes equinus exists, as by that means alone the foot can be placed flat on the ground.

Talipes calcaneo-valgus and pure flat-foot are favored by lax ligaments, and the latter may be a progressive deformity, which increases

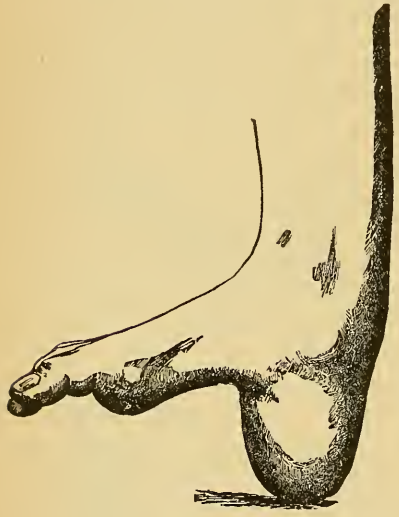

FIG. 442.—Pes Cavus.

FIG. 443.—Both Feet of Patient with Paralysis of All Posterior Muscles Except the Peronei. (Goldthwait.)

until a stage is reached in which the inner malleolus almost touches the ground and the foot can be flexed until the dorsum touches the skin over the tibia. The bearing of body weight on a foot, the ligaments and muscles of which are weak, tends to produce flat-foot.

Pure talipes calcaneus seems to be the result of the paralysis of the posterior calf muscles combined with the action of gravity and superincumbent weight. What is known as pes cavus is more common than pure talipes calcaneus.

The order of frequency of the different forms of deformity from anterior poliomyelitis is as follows: (1) talipes equino-varus; (2) calcaneo-valgus; (3) equinus; (4) calcaneus or pes cavus.

Deformities of the arms are comparatively uncommon as the result of infantile paralysis. The least infrequent of these results from the paraly-

[1] Ross: "Dis. of Nerv. Syst.," Wm. Wood & Co., 1878, p. 942.

sis of the deltoid. In addition to the inability to raise the arm from the side, there is a flattening of the shoulder and a prominence of the acromion process, and the shoulder presents an angular rather than a rounded outline. The ligaments are loosened, and the arm hangs loosely, so that in some cases a wide gap may be observed between the acromion and the humerus.

Any distortion of the arm and hand further than the flaccid condition resulting from the paralysis is quite rare. If contraction does occur, it follows the type to be seen in adult hemiplegia: flexion of the elbow, hand, and fingers. The commonest paralysis of the hand is one affecting the adductor muscles of the thumb, as a result of which the thumb is drawn back to a level with the other fingers and the power to oppose it to the other fingers in grasping is thus lost. Flexion of the hand and fingers may be observed, or flexion of the hand with some mobility of the fingers.

FIG. 444. — Talipes Equinus from Infantile Paralysis, with Slight Valgus.

Infantile paralysis of the sterno-mastoid muscle is recognized as an occasional cause of wry-neck. Paralysis of the intercostal muscles rarely causes deformity, but Gowers saw a case in which a permanent depression in one side of the thorax resulted from such a paralysis. Paralysis of the erector spinæ muscles results in a permanent arching of the spine and inability to sit erect. Paralysis of the abdominal muscles causes lordosis.

Lateral curvature of the spine results from infantile paralysis in one of three ways.

(1) From the inequality in the length of the legs (due to paralysis of one leg), causing tilting of the pelvis. (2) From the unilateral paralysis of the muscles directly controlling the vertebral column, which might be either a paralysis of the intrinsic spinal muscles or of the erector spinæ group on one side. (3) From faulty spinal attitudes assumed in consequence of some paralysis elsewhere, as in paralysis of one arm, or of the serratus magnus, or even of the sterno-mastoid. These cases have been more particularly considered under the head of lateral curvature.

Dislocations from Infantile Paralysis.—Dislocation, complete or partial, belongs to the more uncommon of the complications of infantile paralysis and characterizes severe cases.

Dislocation of the hip is the one most commonly met and it takes place either spontaneously or in consequence of weight being borne upon a limb which is improperly supported by its ligaments. It occurs only

in cases in which the paralysis is severe and of long standing, and it may disable the leg on account of the laxity with which the femur articulates with the pelvis. A shortening of one or two inches may be present, as the dislocation is generally on to the dorsum of the ilium; but sometimes it takes the form of a laxity of the joint in all directions, so that the

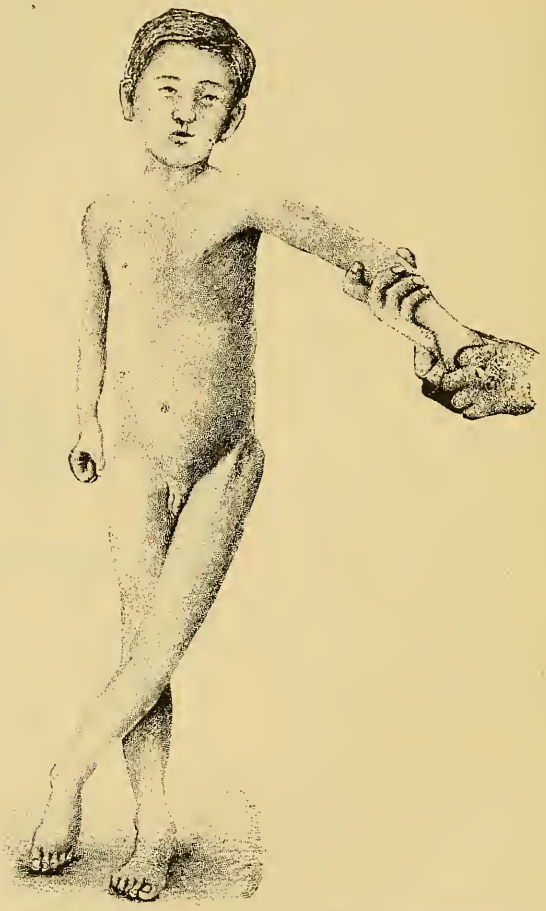

FIG. 445.—Dislocation of Hip, the Result of Infantile Paralysis. In this position the head of the femur (left) is in place, but with abduction it slips out again.

head may be thrown into any position by manipulation of the shaft. Most dislocations of the hip are inconvenient chiefly because of the shortening and insecurity which follow the displacement of the head of the bone. But the head of the bone in a year or two becomes often quite firmly fixed in its new position and such legs are sometimes nearly as serviceable as they were before. Dislocation may, however, occur before any weight is borne upon the affected limb, by the spontaneous action of

the muscles, as in a patient eighteen months old in the experience of one of the writers in which dislocation of one hip took place at the age of three months. In this case the dislocation was reduced under an anæsthetic, and by the application of a plaster-of-Paris bandage the head of the femur was permanently retained in the acetabulum. These dislocations are rarely attended by much pain and are often overlooked by the parents.

Laxity of the knee-joint, so that the joint surfaces slip by each other in the motions of the joint, is a less common affection, but is sometimes seen. In these cases the joint is subluxated at each step.

The subluxation of the tibia in severe cases of knee flexion and the dislocation of the shoulder after paralysis of the deltoid muscle have been already mentioned.

Diagnosis.

In typical cases the diagnosis of infantile paralysis is not difficult. But in other than typical cases the recognition of the disease may be extremely difficult, and it is never easy to establish a positive diagnosis in the initial stage. At that time the occurrence of localized pain may be a misleading symptom, and sensitiveness of the affected limbs may suggest rheumatism. The occurrence of convulsions and unconsciousness may divert the attention to the brain, and all sorts of side issues may be suggested by the manifold symptoms of the onset of the disease. The affection is often wrongly classed as cerebrospinal meningitis at the earliest stage, as the head is sometimes drawn backward in severe cases.

The diagnostic points upon which the practitioner must rely are the sudden onset, a motor paralysis, rapid muscular wasting, the distribution of the paralysis (mostly monoplegic and very rarely hemiplegic), and the loss of the tendon reflex. Diagnosis by the determination of the electrical reaction of the muscles requires especial training and skill, although it is distinctive and the most reliable test at our command.

Electrical Condition of the Muscles.—The electrical reactions in infantile paralysis are clearly marked and characteristic when they can be obtained. Faradic irritability of the affected muscles and nerves begins to diminish within a day or two of the onset of the paralysis, and in muscles severely affected the electric irritability disappears entirely; in the muscles less seriously involved it is merely diminished. This constitutes a valuable symptom in prognosis, as in muscles which are completely paralyzed *faradic irritability is permanently lost by the second week.* But even in later years it may be possible to find in such muscles a trace of irritability to the faradic current by thrusting a hypodermic needle into the muscular substance and transmitting the current through

that. But the change in reaction to the galvanic current is even more important. Normally when this current is passed through nerve and muscle, a quick sharp muscular contraction takes place at the opening and closing of the current and the muscular contraction should be greater at the closing of the negative pole than when the positive pole is closed. The cathodal closing contraction should be normally greater than the anodal closing contraction. When nerves and muscles affected by anterior poliomyelitis are examined, not only a slow wave-like response to electricity instead of a sharp quick jerk is found, but the electrical formula is reversed and *the closure of the positive pole gives the greater contraction.* In general a much stronger galvanic current is needed to produce a contraction in these paralyzed muscles than in normal ones. These qualitative and quantitative changes in reaction to the galvanic current constitute what is known as the "reaction of degeneration," and this affords the most definite ground for the diagnosis of infantile paralysis. But such an examination to be of any value requires practice and special skill in the use of electricity. In young children the examination often yields no results even to a specialist in nervous diseases on account of the child's constant activity, and although it is the most definite means of diagnosis that we possess in obscure cases, its use is attended with many difficulties.

The only affection which may not be distinguished by electrical examination from anterior poliomyelitis is peripheral paralysis caused by interruption in the course of some nerve.

Differential Diagnosis.

The leading points which are to be depended upon in the differential diagnosis are these: Infantile paralysis is purely a motor affection and sensation is never permanently impaired. The reflexes are generally diminished or lost. Wasting is rapid and extreme and the leg is cold and blue in severe cases. The "reaction of degeneration" is present in electrical examination.

Cerebral paralysis generally begins with a sudden onset, and often convulsions are present and the child is found to have lost the use of one side of the body. It differs from infantile paralysis in these points: Its distribution is hemiplegic and facial paralysis is common, the tendon reflexes are increased from first to last, faradic excitability is not lost, and the galvanic formula is normal; later the intelligence is generally affected and atrophy is neither so marked nor so rapid as in infantile spinal paralysis, but similar contractions of the joints of the affected limb come on. These contractions are, however, often spastic in character. Allusion must be made to the importance of electricity in making a differential diagnosis, which is often attended with much difficulty. A hemi-

plegic distribution of infantile spinal paralysis is rare,[1] but cases have been reported in which the facial nerve was involved.[2]

TABLE OF THE DIFFERENTIAL DIAGNOSIS OF INFANTILE PARALYSIS AND CEREBRAL PARALYSIS.

	Infantile Spinal Paralysis.	Cerebral Paralysis (Hemiplegia).
Age.	Sharply limited to children in first dentition.	Not sharply limited to young children.
Onset.	Sudden, but severe convulsions not often present.	Sudden, and severe convulsions generally present.
Distribution of paralysis.	Oftenest monoplegia or paraplegia; rarely involves facial nerve.	Hemiplegia; generally involving facial muscles on one side.
Reflexes.	Lost generally.	Increased.
Electrical reaction.	Faradism, diminished or lost.	Faradism, normal.
	Galvanism, formula reversed (reaction of degeneration).	Galvanism, normal.
Mental impairment.	Absent.	Likely to come on.
	Spastic condition absent.	Spastic condition of one or both legs often follows.

Both affections are characterized by motor paralysis, wasting and retarded growth of the affected limb, and contractions of the joints.

Progressive muscular atrophy in childhood is a very rare affection, but it has been observed, sometimes beginning in the legs. Its onset is gradual, and the faradic excitability remains so long as there is any muscular substance left and the galvanic formula remains normal. The reflexes are not lost until all muscular substance has gone.

Acute transverse myelitis of the dorsal region causes paralysis of the legs when it occurs, but unless the lumbar enlargement is involved there is no loss of electrical irritability. Reflex action after a day or two is much increased and ankle clonus can be obtained. There is generally paralysis of sensation, and bed-sores develop with much rapidity, while any wasting is very gradual. There is no change in the electrical formula.

A paralysis much like that in anterior poliomyelitis has been described by Bullard following *cerebrospinal meningitis*. In such cases pain and tenderness of muscles persist longer than in infantile paralysis. There is a tendency to spastic contraction in the early stages which becomes less later. The knee jerks on the whole are less affected than in infantile paralysis; they may, however, be absent entirely.[3]

Diphtheritic paralysis may offer serious difficulty in diagnosis, because

[1] Duchenne and Seeligmüller (3 cases), Sinkler (4), West (5), Heine (1), Leyden (1), Duchenne (1).

[2] Henoch: Loc. cit., p. 203; Barlow: Loc. cit., p. 76; Seeligmüller.

[3] Boston Med. and Surg. Journ., vol. i., p. 159, 1899.

anterior poliomyelitis may occur in the course of a diphtheritic attack as in any other infectious disease. The paralysis of diphtheria affects oftenest the muscles of the palate and fauces, the electrical reactions remain normal, and severe atrophy is not present.

Pseudo-hypertrophic paralysis in its early stages is not likely to be confused with infantile paralysis, for it is generally characterized by much increase in the size of the muscles, which is extensively distributed and comes on very gradually and is not accompanied by any marked electrical changes. Late in the affection marked muscular atrophy occurs, but it is generalized and the history would clearly differentiate the condition from anterior poliomyelitis.

Paralysis may result from lesion of a peripheral nerve, as in instrumental delivery at childbirth, from tight bandaging, etc. But its distribution is limited to a single nerve or group of nerves and it is characterized by a concomitant affection of sensibility. The electrical reaction would be the same as in infantile paralysis.

The so-called rhachitic paralysis might offer some difficulty of diagnosis. But it occurs in the acute stage of rickets and is not a paralysis so much as a disinclination to use weak and tender limbs. It is accompanied by general tenderness and to a certain extent by the diagnostic signs of rickets, the reflexes are normal and its onset is more gradual. It is, however, so early a complication of rickets that its recognition may offer difficulty.

Practically infantile paralysis of one leg sometimes simulates at first slight congenital dislocation of the hip, but only inattention can account for a mistake in the diagnosis. In congenital dislocation the trochanter would be above Nélaton's line, it would yield to traction, atrophy would be very slight, and the electrical reaction normal.

With hip disease, infantile paralysis is at times confounded in practice. The onset of the paralysis may be accompanied by joint pain and tenderness, and on the other hand hip disease is accompanied by serious muscular atrophy and a modification of faradic irritability of the muscles, as Shaffer[1] has shown. But the distinguishing feature of hip disease is muscular fixation, and that is not present in infantile paralysis, in which muscular laxity is the prevailing condition. The onset of hip disease, although generally gradual, may at times be apparently sudden.

Prognosis.

So far as danger to life is concerned, the outlook in infantile paralysis is very favorable, for few patients die in the acute attack. When death does occur it is generally at the end of a week or ten days. Continued cerebral symptoms, however, are of grave significance. In cases in which

[1] N. M. Shaffer: Archives of Medicine, New York.

the deformity is only of moderate extent, it is not probable that life will be shortened by it.

It is not likely that the paralysis will increase any more when it has been stationary for twenty-four hours. Second attacks are very rare, and when they do occur, they come on within a day or two of the original attack and are made evident by an increase of the existing paralysis.

The tendency of the paralysis, as we have seen, is toward improvement and partial recovery. The law of Duchenne gives the keynote to a more exact prognosis in establishing the fact that all the paralyzed muscles in which the faradic irritability is only more or less diminished, but not completely lost, during the course of the second week, do not remain permanently paralyzed, the restoration being more prompt and complete the less the faradic irritability has been diminished. In general when the faradic irritability is lost at once, paralysis will be severe and to a certain extent permanent. When the irritability is lost later, the paralyzed muscles will improve slowly and nearly recover. When faradic irritability is not lost at all, recovery will take place in a few weeks or months. Without the use of electricity one has to wait much longer before giving any more definite prognosis than a general promise of improvement.

When untreated, a case of infantile paralysis will almost invariably improve for one or two months at a rapid rate, then more slowly for two or three months more, and then after a stationary period, contractions, looseness of the joints, and malpositions are likely to begin, which may increase indefinitely. Under treatment the prognosis is much more favorable and the limit of possible improvement extended by many years. There is scarcely any leg, however wasted and contracted, that is not amenable to improvement by operative or mechanical treatment.

It should be remembered that even in mild cases of infantile paralysis bone shortening is liable to follow. It is very variable atrophy, and certain severe cases escape with but little, while a mild case of talipes valgus may show, with the wasting of the leg, a shortening of one or two inches in the limb of the affected side, or in exceptionally severe cases, shortening of several inches.

Treatment.

The treatment of infantile paralysis varies according to the stage at which treatment is to be undertaken.

The Stage of Onset.—If the fact that paralysis is present is established during the febrile attack, which is usually the first symptom of the disease, vigorous treatment should be at once begun, to limit, if possible, the destructive process in the cord. Cathartics should be given at once, the patient should lie on the side or the belly, to prevent stasis of

the blood in the spinal cord, and counter-irritants or cups should be applied over the spine. Ergot should be administered in doses of ten drops of the fluid extract, three times a day, for infants of six months, and half a drachm for children of one or two years. Bromide of potassium and of sodium are recommended on the ground that they contract the capillaries of the spinal cord. The general condition of the child should in every way be kept as good as possible. Antipyretics may be indicated.

The Stage of Paralysis.—But few cases are seen by the surgeon until the stage of paralysis is present, when treatment by medicine is manifestly of little avail. The question that then presents itself is in regard to the treatment of the paralysis, in order that the ultimate amount of muscular power may be as great as possible. It must be remembered that the tendency of the paralysis is at first very strong toward spontaneous improvement. It is therefore manifest that in the first few weeks treatment should be directed toward producing conditions which shall be as favorable as possible for that improvement to attain its maximum.

The object of treatment in this stage should therefore be first to support the affected limb in a normal position, and most carefully guard against the stretching of joints and ligaments and muscles; and, secondly, by the use of electricity, massage, and systematic exercise to keep the nutrition of the affected muscles in the best possible condition. In this way only, by beginning the treatment at the first, can the best possible ultimate result be obtained.

It has been seen that what may be called protective treatment should be begun at once, and from the first the diseased limb should be placed and retained in a normal position, so that the affected muscles and joints may be supported and kept at rest. In this way the enfeebled muscles are placed under the best possible conditions for their recovery. To allow attention to be diverted from these very important measures to pursue a medical treatment whose utility is doubtful, is manifestly irrational. In paralysis of the legs the feet should be supported from the first at a right angle, in their normal position, by some simple splint or similar appliance, and the weight of the bed clothes should be kept off of the toes.

The appliances needed to maintain in a proper position the limbs of a patient with paralysis will vary according to the parts affected and will demand some ingenuity on the part of the surgeon. In severe and extensive cases light bed frames may be very useful to allow the patient to be carried about, while retaining the limbs in a proper position. So far as possible in such cases bandages should be avoided, and straps should be used instead, as the surface circulation is feeble and likely to be impeded by bandages.

When the arm is paralyzed, a sling should be worn to prevent dragging of the arm upon the shoulder-joint ligaments and the weakened deltoid muscle.

Electricity is a most useful therapeutic measure in the early stages of the paralysis. Treatment should be begun as early as the spinal irritation seems to have disappeared, probably about the end of the first week, and continued indefinitely, but not to the exclusion of proper mechanical treatment. The galvanic current is used, a very gentle current is passed through the affected muscles and nerves for a few minutes each day, and muscles which contract only feebly to faradism should be daily stimulated by the application of the faradic current. Muscles which will not contract to faradism can sometimes be much improved by applications of the interrupted galvanic current. The chief use of electricity, it is to be remembered, is to stimulate to contraction the paralyzed muscles, thereby affording a sort of gymnastics. Probably electrical treatment receives much credit in the treatment of this disease, which is not properly due to it, for it is employed at a time when marked improvement is almost certain, and very much the same results can be obtained by methods about to be considered. One sees cases in which it has ceased to benefit the child and has been persisted in to the exclusion of more rational treatment for that especial case. But even in the late stages of the disease, when wasting and deformity have come on, the use of electricity may at times lead to an improvement of nutrition.

Dry warmth and rubbing are measures which seem of equal, if not of greater, value in the stage of simple paralysis. Heat is easily applied by having the child sit in front of a fire or stove with the leg thrust through a hole in a sheet of pasteboard. This serves as a screen to the rest of the body, while the affected member is allowed to become thoroughly warmed once or twice a day either in this way or by a hot-air oven. During the day, especially in cold weather, the paralyzed limb should be protected by two thick stockings and a warm boot. Any treatment which stimulates the circulation of the paralyzed limb aids in its recovery by improving the nutrition of the muscles, and dry heat very effectually accomplishes this end. A paralyzed leg should be thoroughly heated for an hour before it is rubbed at night.

Massage is another most important element of treatment in this as in any stage of infantile paralysis after the initial irritation has quieted down. Skilled massage, when it can be obtained, is of course better than friction at the hands of the parents, but the latter is a simple and efficient treatment, which lies within the reach of most people.

In the place of the usual manual massage, mechanical massage of the limbs has been employed by means of carefully constructed appliances. This, however, will be within the reach of but few.

Active muscular exercise of the paralyzed limb is a most desirable

tonic to the affected muscles, however it is obtained, provided the muscles be not overtaxed. With the assistance of the parent's hand, a foot which naturally drops forward from paralysis of the anterior leg muscles can be flexed, and with each repetition of the exercise the muscle will be found able to accomplish more. It is impossible to lay down any series of exercises. In each case the problem must be met differently. The aim should be so to assist the affected muscles that if they have any power left they may be enabled to use it daily for their own advantage. And with this in view, assistance should be rendered by supporting and aiding the affected limb in its movements in the way most likely to call into use these paralyzed muscles. Such exercise forms a most useful adjunct to the massage. It should be repeated each night just before or just after the massage.

H. L. Taylor, in an excellent paper on the hygiene of reflex action, says: "In the neuromuscular degenerations following acute anterior poliomyelitis, it is especially important to restore to the paretic extremities, so far as possible, the stimuli of locomotion and other normal associated movements without the inhibition of insecure footing and strained tissues—and it is for the specific purpose of restoring to the damaged cord and muscles the cutaneous, muscular, and articular stimuli of locomotion that apparatus is constructed.

"Normal reflexes of locomotion are broken up, and a wasteful and cumbersome set installed, subject to constant cerebral interference in the efforts at balancing and progression, and additionally disturbed by the strain in weakened muscular and joint structures which is rendered inevitable by the lack of balance between opposing groups. Mechanical protection with muscular training enables the patient to acquire a better set of reflexes and promotes the nutrition of the part."

Mechanical Treatment.

The mechanical treatment of this disease often presents a most difficult problem. Absolute accuracy in the fitting of the apparatus is an essential, and the varying indications make necessary constant modifications in the appliances to be used.

The mechanical treatment of infantile paralysis is twofold in its object. The first and simplest use of apparatus is to support and protect the paralyzed limb in such a way that the muscles shall work to the best advantage and that the joints may be supported and controlled. By doing this the occurrence of contraction deformities is prevented and the nutrition of the limb is kept in the best possible condition by enabling the limb to be used in a comparatively normal way.

The second function of mechanical treatment in infantile paralysis is to overcome by means of suitable appliances deformities which have

already occurred and to prevent their recurrence; it may often be necessary to attempt both objects with one apparatus.

The Indications for Mechanical Treatment.—Whenever a paralyzed limb is unable to bear the weight of the body which falls upon it in locomotion, some mechanical help is manifestly advisable. This is not only needed when the paralysis is complete, but also when, owing to incomplete muscular strength, more strain is borne on the articular ligaments than is normal. Moreover, when the bearing of the body weight or the act of walking throws the foot or the leg into any abnormal position, the use of some appliance is indicated. It is difficult to describe the various appliances needed in the treatment of infantile paralysis, and much must be left to the ingenuity of the surgeon in each case.

The first division of the mechanical treatment of these cases consists in furnishing sufficient support to the limb in the following conditions:

1st. Paralysis of the muscles of the legs and feet.

2d. Paralysis of the muscles of the thigh.

3d. Paralysis of the muscles of the back.

And a combination of these various paralyses.

Paralysis of the Leg.—When the muscles of the leg are paralyzed, those which help to control the ankle-joint in standing and walking are rendered inefficient and the ligaments may become relaxed so that in the standing position the ankle of the affected side cannot sustain the body weight as it should, and the foot is apt to roll in or out, causing an inversion or eversion of the foot amounting to a degree of talipes varus or valgus.

In any apparatus which is to sustain the foot in its weight-bearing function, accuracy of support is indispensable, and a simple leather boot, however stout it may be, soon yields and the foot slips away from the rest of the apparatus, and the efficiency of the brace is impaired; a rigid sole is, therefore, essential for any apparatus which is to control the ankle properly, and this can easily be accomplished by having a thin steel plate inserted between the layers of the sole of the boot.

When no contraction or deformity exists at the ankle, but there is simply a tendency of the front of the foot to drop on account of the affection of the anterior muscles of the leg, locomotion can be made much more easy by preventing this. A common appliance for this latter deformity is an ordinary shoe fitted with lateral steel uprights and a posterior steel calf band. There is a right-angle stop catch at the ankle which keeps the foot from being fully extended.

The same end can be better accomplished by the application of a walking appliance, described under club-foot as a varus shoe, which should be provided with a right-angle stop at the ankle which will not allow the ankle to be extended to more than a right angle. When in bearing weight

upon the leg the ankle assumes a varus position, the same varus shoe will correct the tendency to deformity.

If the foot rolls out and is everted into a valgus condition when the body weight is borne upon the leg, an outside shoe is to be applied, in construction like the varus shoe, but which should have a broad leather strap which should pass around the inner malleolus and support it. This apparatus is a difficult one to render quite comfortable to the patient, as much weight must necessarily come upon the strap which supports the

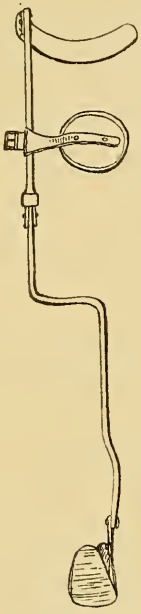

FIG. 446.

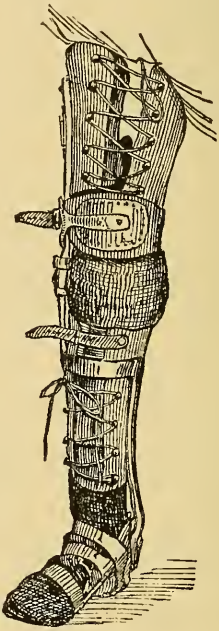

FIG. 447.

FIGS. 446 and 447.—Splint with Single Upright for Infantile Paralysis of Right Leg with Varus Deformity of Ankle; unapplied and applied.

inner malleolus. As flat-foot is almost always present in these cases, it is well to arch the steel sole plate of this apparatus so that it serves as a valgus plate as well as a supporting appliance.

It is manifest that the simpler and lighter these appliances are and the less unsightly, the more serviceable they will prove. For this reason they should be carefully fitted and the uprights made to follow the outline of the leg. In very slight cases, in which there is only a slight eversion of the foot with a small degree of valgus, a common valgus plate, such as would be applied for flat-foot, will often answer every purpose in correcting the deformity, and it should be applied as in simple flat-foot.

In severe cases of paralysis of the muscles of the legs and foot, the thigh muscles may be involved. The same appliance will often have to

support the knee and thigh as well as to correct deformity at the ankle. But this involves merely an extension of the apparatus up the leg.

Paralysis of the Thigh Muscles.—When the muscles of the thigh are involved in the paralysis, the limb becomes unable to sustain the weight thrown upon it and the knee flexes and the limb drops forward when weight is borne upon it. The knee-joint does not bend to one side or the other, as the lateral ligaments retain much strength. In a few instances the knee will drop backward to more than a straight line, but owing to the strength of the crucial ligaments in infantile paralysis it never falls so far back as to be unable to sustain weight. For the practical purposes

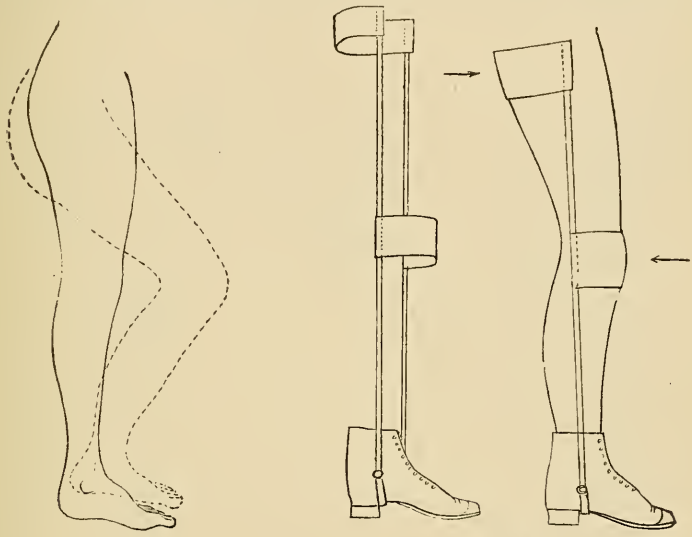

FIG. 448. FIG. 449.

FIGS. 448 and 449.—Supporting Apparatus in Paralysis of Anterior Thigh Muscles.

of locomotion, therefore, it is only essential that the knee be prevented from dropping forward, and this can be done by means of any appliance which will press the knee backward. The simplest way of doing this is by the use of two steel rods reaching from the back of the thigh to the bottom of the shoe. These rods are placed on the outer and inner side of the limb and are connected at the top by a posterior steel band, which furnishes a counterpoint of pressure by which to hold the knee. If a strap is passed in front of the knee, it is impossible for it to drop forward when weight is thrown upon the leg, and the patient can stand upon the limb. The appliance supplies the check normally exercised by the muscles. Below it should be fitted to a boot, or if the muscles of the leg are also involved, to one of the appliances such as the varus or valgus shoe mentioned above. The principle of such apparatus in retaining the knee extended is shown in Figs. 448 and 449.

Instead of being applied by means of a steel sole plate, the apparatus may be fastened to the sole of the boot. In addition to the bands shown in the figure, leather lacings to retain the thigh and calf will probably be needed to give the apparatus greater stability, as the lacings, by covering

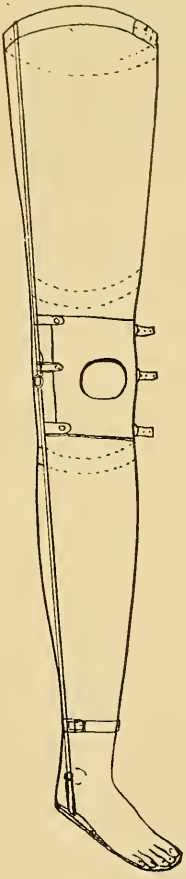

FIG. 450.

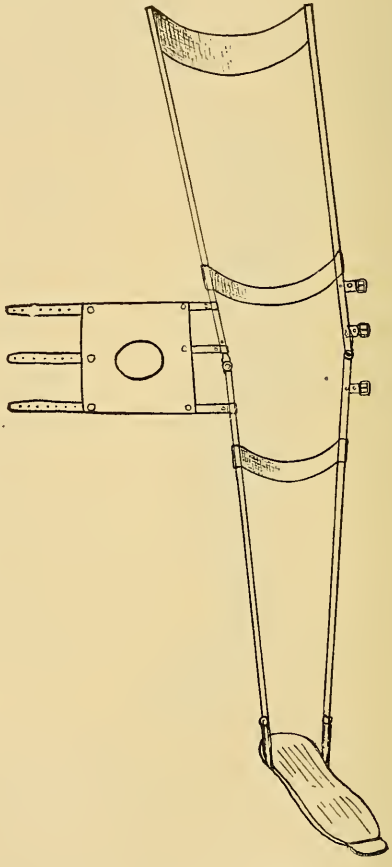

FIG. 451.

FIGS. 450 and 451.—Supporting Apparatus for Infantile Paralysis of Leg and Thigh, with Knee-cap.

a large area of skin, substitute surface pressure for the point pressure given by narrow straps. This is a matter to be considered in all supporting apparatus.

If the knee tends to drop backward and become hyperextended, it can be remedied by a similar appliance with a strap passing behind the knee, with an upper band encircling the thigh. In practice this apparatus can often consist of a single outside upright hinged at the knee. It passes to the inside of the leg just below the knee to become attached to

a varus shoe. This answers as well as a double upright in many cases. The apparatus can be hinged at the knee for convenience in sitting down and should be furnished with leather lacings for the thigh and calf (see Figs. 446 and 447.)

Other cases, in which the paralysis is more severe, require the two uprights, as they furnish a more definite support. The foot is easily retained to the steel sole plate by straps or a piece of leather lacing over the instep. The fenestrated knee cap is the most comfortable method of holding the knee extended (Figs. 450 and 451).

Although in walking it is generally necessary to have the knee kept extended by the splint, yet in sitting down it is a great comfort to the

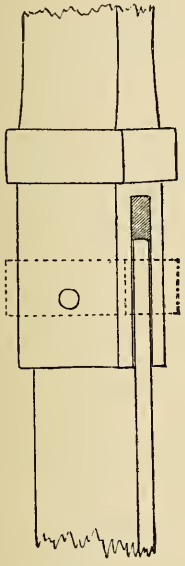

FIG. 452.—Drop-catch.

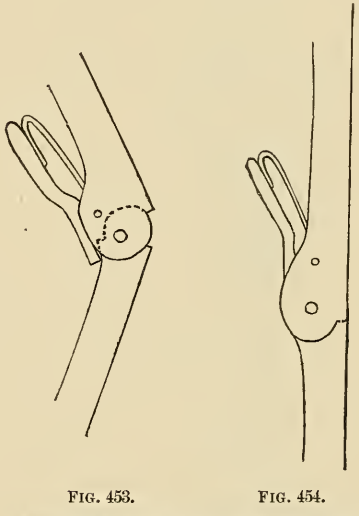

FIG. 453. FIG. 454.

FIGS. 453 and 454.—Self-locking Spring-catch.

patient to be able to flex the knee, and for this reason nearly all splints should be hinged at the knee.

A great variety of hinges can be applied at the knee with different catches, enabling the patient to bend the limb by loosening the catch or locking it when it is desired that the limb should be stiff. The simplest and most economical of these is the simple drop catch shown in the figure. When the limb is straightened, the ring falls down and locks the splint in the extended position, but it can be pulled up at any time, allowing the knee to bend.

In another and more expensive form the splint is self-locking, and the bending is made possible by pressing a handle at the outside of the knee.

When the adductor muscles are affected, little or nothing can be

done to supplement them by mechanical means without employing heavy apparatus, inasmuch as their loss of power occurs only in extensive paralysis. This can be done by encircling the pelvis by a stout leather band which is connected with the leg appliance by joints at the hip. The appliance shown in Fig. 456 is a useful form of this sort of apparatus, and even in very extensive paralysis of both legs it may furnish much support. Little can be done to remedy paralysis of the glutei muscles, but when paralysis of the legs appears to be complete, a certain

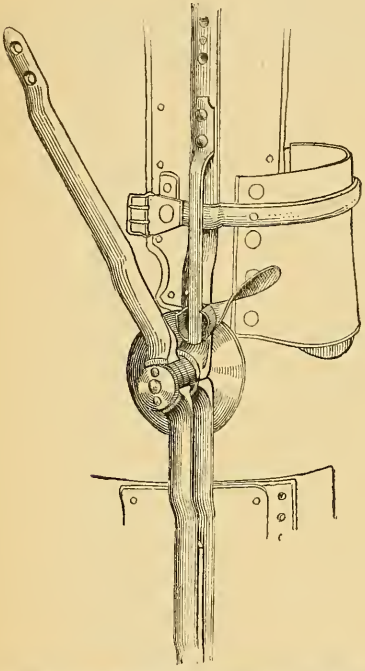

FIG. 455.—Mechanism for Locking Knee-joint. (H. L. Taylor.)

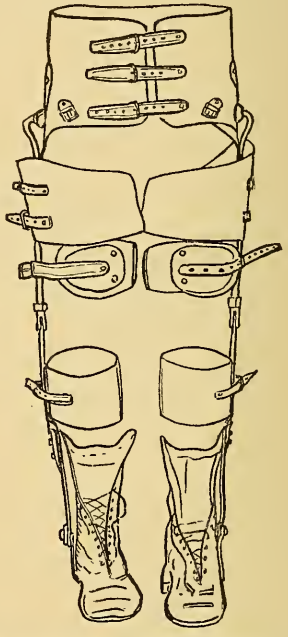

FIG. 456.—Burrell's Splint for Complete Infantile Paralysis of Both Legs.

amount of relief may be given by attaching the leg uprights to a leather or silicate jacket. The common Thomas knee splint may be joined to a leather jacket by lateral uprights jointed at the trochanters.

The muscles of the back are rarely if ever paralyzed, except in connection with palsy of some of the muscles of the leg. Complete paralysis of the muscles of the trunk indicates an extent of disease which is most distressing. When the muscles of the back are but partially affected, help may be afforded by the use of corsets or other supporting appliances, such as are employed in the deformities of the spine. These can be connected with the leg appliances and will afford assistance in standing. Cases of this sort may be so severe as to require the use of crutches

for rapid locomotion, but much assistance may be afforded by appliances in many cases.

The abdominal muscles are sometimes, though rarely, affected, giving a protuberant abdomen, and a position of much lordosis in standing. Waist bands or corsets will serve to correct the appearance of the trunk to a certain extent.

The mechanical treatment of infantile paralysis of the arm is not a question which arises often enough to make it worth while to enter upon any discussion of it, save to mention that the principles of treatment are the same as those already considered.

The use of elastic bands to supply the place of the disabled muscles is thought in some instances to be sufficient to compensate for the action of the paralyzed muscles. It will, however, be found that an elastic support, inasmuch as it is not of certain tension, is necessarily a varying support and adds to the complicated nature of the appliance rather than to its efficiency, nor is it possible to gauge accurately the force or pressure exerted at any time. It is generally, therefore, a much less efficient form of apparatus than the rigid forms here advocated.

Mechanical Treatment as Applied to the Correction of the Deformity.—Whether the deformity shall be corrected by purely mechanical means or by operative interference depends not only upon the nature of the distortion, but also upon the time at the disposal of the patient and surgeon. Many of the distortions of this sort can be cured in children without any operative interference, as all that is required is the stretching of the fasciæ and the contracted tendons. These distortions are either flexions at the hip or knee or some distortion of the ankle. The less severe of these distortions yield readily upon the application of efficient force.

Deformity at the hip, which is generally flexion, with perhaps abduction, is the hardest of all the deformities of infantile paralysis to correct by mechanical means on account of the difficulty of securing a fixed hold upon the pelvis, by which a point of resistance can be secured in overcoming the flexion of the thigh. A simple apparatus which is often of use is furnished by two caliper Thomas knee splints, or one, as the case may be, attached to a leather jacket by side irons hinged opposite to the hips. To the posterior and upper parts of the splints are attached straps which buckle to the back of the jacket, and while by the jacket as firm a hold as possible is taken on the pelvis, when the straps are buckled the caliper splints pull the legs backward and tend to overcome the flexion at the hips. During this time the child should go about on crutches.

But the contraction is sometimes resistant, and it is necessary to confine the patient to the bed and to employ traction of a considerable amount and such measures as have already been described in correction of the flexion deformity of hip disease.

Attempts to use the weight of the leg to correct this flexion in severe cases are of little use. It might be imagined that if the knee were straightened by a ham splint, and the patient allowed to go about on crutches with the leg projecting in front of him, the weight of it by dragging upon the shortened tissues would stretch them and the flexion would be diminished. But the leg hangs almost perpendicularly down in these cases, owing to a compensatory lordosis in the lumbar spine, which takes place at once. This is due to the rotation of the pelvis upon its transverse axis, which occurs naturally enough under the influence of the weight of the leg and which occasions no inconvenience to the patient. A similar proceeding occurs when a weight is applied to the patient's leg lying in bed, so that it becomes inefficient also. In the severer cases operative treatment is indicated.

Flexion of the knee is due to a contraction of the hamstring muscles. The deformity in children, except in severe cases, can be corrected by bandaging the leg to a splint which takes pressure above on the under side of the thigh and below is fastened to the heel. The appliance is similar to that described above as a support to the knee. In resistant cases some pain is experienced in this procedure, but the pain is not great. Patients with severe deformity should be confined to bed during the application of this method of treatment, but in the milder cases they may be allowed to go about.

The simplest of all forms of correction in contraction of the knee is the Thomas knee splint or a modification of it, but jointed splints will be found convenient in some instances of the severest type. If the Thomas knee splint is applied, a bandage should be applied in front of the thigh and behind the calf; by tightening these a decided extension force is exerted upon the knee.

An admirable brace for correction of the knee is one similar to the simple supporting brace with two uprights already described, except that it should be jointed at the knee and furnished on one side with a worm screw and ratchet, so that by the use of a key the splint can be set with any desired angle at the knee. A leather knee cap is sometimes necessary to obtain counter-pressure against the knee in front, but in other cases the thigh and calf lacings are sufficient to obtain any desired leverage. These leather lacings should fit with especial accuracy in this form of appliance. To be applied the splint should be flexed to fit the contracted knee and put on and laced firmly. Then with the key it should be extended nearly to the point of endurance and worn as straight as it can be borne for an indefinite time. At first these joints prove very sensitive and painful, but they soon become used to the tension and then rapid progress can be made. The extension of a contracted knee may in the case of an adult be a matter of many months, but in children it requires less time, unless it is severe, when operation may be

required. The deformity shows a strong tendency to recur when the apparatus is removed.

It would hardly be possible to reduce the knee flexion by bandaging the leg to a ham splint and making traction upon the knee; the resistance is too obstinate except in very slight cases. Correction by the repeated application of plaster bandages to the knee, extended as much as possible, will often be found satisfactory and painless to the patient. The method, however, is a slow one in resistant deformities.

Deformities of the Foot.—The treatment of the deformities of the foot caused by infantile paralysis differs very little from that described in the chapters describing deformities of the foot. Those from infantile paralysis, however, are rarely so resistant, and yield more readily to mechanical treatment. Talipes equino-varus and varus are ordinarily to be corrected by the varus shoe, so often described. In severe cases which seem resistant, and in adults, tenotomy will save time and annoyance. Talipes valgus is rarely the result of contraction, but exists more as a purely static deformity, the treatment of which has been already considered.

Talipes calcaneus and pes cavus are not susceptible of much improvement by mechanical treatment. Apparatus which depends for its efficiency upon a strap encircling the instep and pressing upon the head of the astragalus fails to accomplish very much. At times it is of use to apply an outside or inside Taylor shoe, as the case may be, with a right-angle stop catch joint at the ankle, which prevents dorsal flexion of the foot further than that angle.

Operative Treatment.—The measures to be considered are:

(*a*) Transplantation of muscles or tendons (tendon anastomosis).

(*b*) Tenotomy or fasciotomy.

(*c*) Forcible straightening.

(*d*) Osteotomy near the deformed joints.

(*e*) Excision and arthrodesis.

(*a*) Tendon transplantation is a procedure by which the proximal ends of healthy or partially affected muscles are attached to the distal ends of the tendons of paralyzed muscles[1] and the action of the healthy muscle is transferred to the attachment of the paralyzed one. For example, when the gastrocnemius muscle and the flexors of the foot are paralyzed, the tendon of one peroneal muscle may be stitched to the tendo Achillis and the tendon of another peroneal muscle to the distal end of the flexor longus pollicis. In this way the contraction of the peronei results in plantar flexion of the foot.

Muscles may also be implanted in other muscles or fasciæ, as, for example, the proximal end of the Sartorius muscle may be sewed to the rectus anticus when the latter is paralyzed and the former is not.[2]

[1] Nicoladoni: Cent. f. Chirurgie, November 5th, 1881.

[2] Goldthwait: Orth. Trans., vol. x.

This method seems to offer assistance in many instances to patients who would otherwise be obliged to wear apparatus permanently. The method is of use only when some muscles of the affected limb retain a practical amount of power. It has no place in the treatment of complete paralysis of a limb.

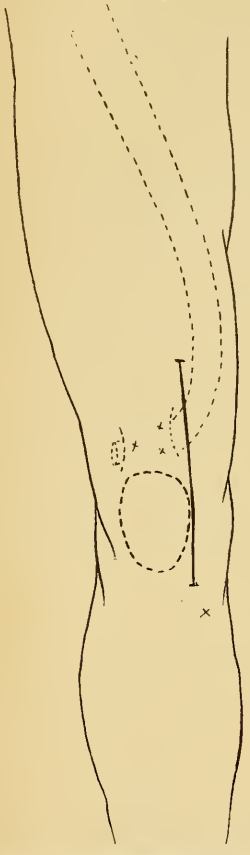

FIG. 457.—Transplantation of Sartorius to Quadriceps Tendon. (Goldthwait.)

Some of the applications of this method already used which have proved practicable are as follows:

Calcaneo-Valgus.—If the peronei are intact the tendon of the peroneus longus is cut from its attachment, passed under the tendo Achillis and attached to the cut end of the tendon of the flexor longus pollicis, while the tendon of the peroneus brevis is cut and sewed to the tendo Achillis. To obtain a muscular action on the inner side of the foot in such cases the tendon of the peroneus tertius and the outer tendons of the common extensor may be attached to the tendon of the tibialis anticus if the latter is paralyzed.

Talipes Equinus.—If the common extensor has escaped, the healthy muscles should be attached to the tendon of the tibialis anticus and the tendon of the peroneus tertius also added to that of the healthy muscle.

Paralysis of the anterior muscles of the thigh may be benefited when the sartorius has escaped by the attachment of that muscle to the tendon of the quadriceps extensor just above the inner side of the patella.

These are far from being all the available applications of the method and each case must be studied individually and anatomically. As a rule, small muscles substituted for large ones hypertrophy and accommodate themselves to their new functions.

The field of operation should be exposed by a long incision exposing the tendons which should be dissected free from their sheaths. Tendons to which the attachment is to be made should be split and the tendon of the healthy muscle passed through and secured by a quilted stitch as described by Goldthwait.[1] The tendon passed through the split should

[1] Boston Med. and Surg. Journ., January 9th, 1896.

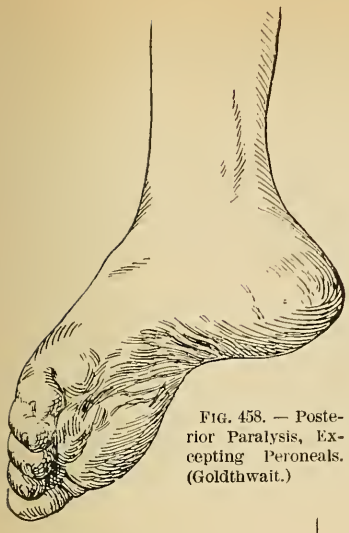

FIG. 458. — Posterior Paralysis, Excepting Peroneals. (Goldthwait.)

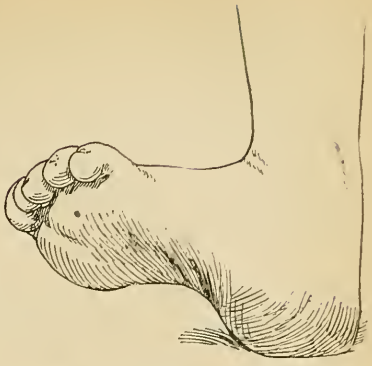

FIG. 459.—Attempted Direct Dorsal Flexion in Same Case. (Goldthwait.)

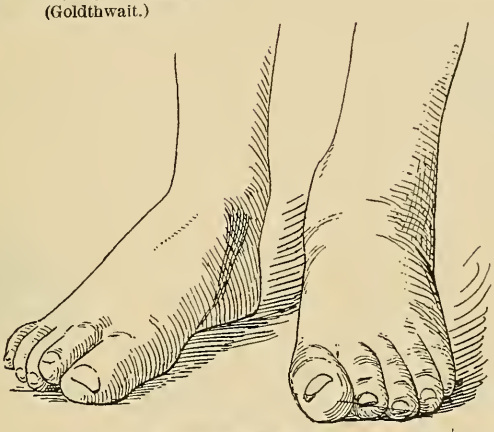

FIG. 460.—Same Case after Operation.

FIG. 461.—Same Case after Operation. Voluntary dorsal flexion.

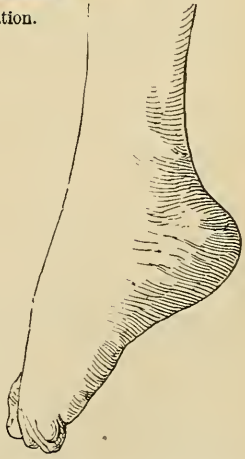

FIG. 462.—Same Case after Operation. Voluntary extension.

be scored by a knife to make the included surface rough. Silk is the best material to use for sutures. To estimate the degree of tension nec-

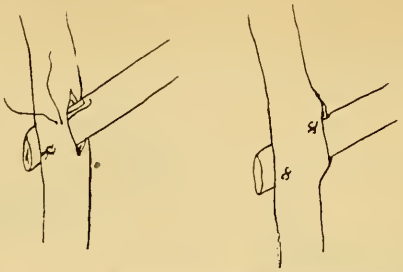

FIG. 463.—Method for Grafting. (Goldthwait.)

essary the foot should be held in a corrected position and the suturing done with a safe degree of tension exerted on the muscle, as the danger lies in making the attached muscle too long. In the case of the attach-

FIG. 464.—Case before Operation. (Goldthwait.)

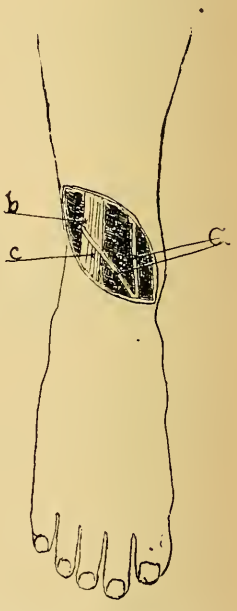

FIG. 465. — Operation. Tendon of tibialis anticus split and attached to the peroneus tertius. (Goldthwait.)

FIG. 466.—After Operation.

FIG. 467.—After Operation.

ment of two small tendons to each other, one of the ordinary forms of tendon suture may be substituted for splitting.[1]

[1] H. A. Wilson: "International Clinics," vol. i., 4th series.

After operation the foot should be put up in plaster in the correct position for some weeks, after which passive motion should be followed by restricted use. Weight-bearing should be begun cautiously and the tendency to deformity corrected by the use of such apparatus as may be needed for a while, and permanently if the substituted muscles are not strong enough to correct the tendency to deformity.

In general, however, it may be said that the operation performed under proper conditions is likely to do away with the future use of apparatus.

(*b*) Tenotomy or fasciotomy is performed in resistant cases of deformity when contracted tissues hold the limb or the joint in malposition. The indications are the same as described in speaking of club-foot and the technique differs in no way from that. Immediate cor-

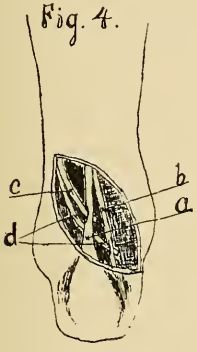

FIG. 468.—Implantation of Peronei on to Tendo Achillis and Flexor Longus Hallucis. (Goldthwait.)

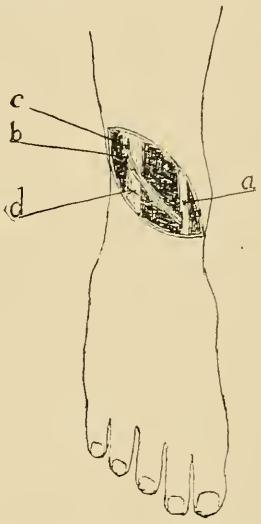

FIG. 469.—Transplantation of Peroneus Tertius and Part of Common Extensor Tendon to Tibialis Anticus. (Goldthwait.)

rection is advisable after tenotomy in this as in other affections, but here over-correction is not necessary. Relapse is less likely to occur than in congenital club-foot.

Tenotomy of the hip for contraction in the flexed position may in the severest cases be far from a trifling operation, and should be undertaken with due reserve. The contraction is due not only to the contraction of the superficial tissues, but of the deep muscles also and often of the joint capsule, and for that reason, when the operation is undertaken in a severe case, it is better not to attempt a subcutaneous tenotomy but at once to make a longitudinal open incision of considerable length over the contracted tissues, and preparation should be made to go as deep as the psoas tendon if necessary. Although the contraction often seems to be superficial, a division of the superficial bands generally gives but little

relief, and all constricting bands must be cut, except of course the capsule of the hip-joint, which often offers resistance. A conservative method to pursue is to cut the superficial contracted tissues and to divide the psoas tendon nearly across, cutting also those deep structures which are plainly in view, in order to be able to check hemorrhage if it begins; then to close the wound and to apply a bed extension to the leg, which will have the effect of stretching the remaining structures quite readily until a corrected position is obtained.

Division of the ham-string muscles at the knee is often required in flexion deformity of the leg. In severe cases an open incision is often more satisfactory than a subcutaneous tenotomy. In cases of long standing not only the tendons but all the structures at the back of the knee are contracted and an extensive division of them may be needed.

(*c*) *Forcible straightening* is applicable to the knee, hip, and ankle, and is, of course, to be done under complete anæsthesia. It is generally better to precede this by tenotomy of resistant tendons.

(*d*) *Osteotomy* may be required to correct severe flexion deformity at the hip, and at the knee to correct the knock-knee and flexion at the same time. At the hip it does not differ from the ordinary Gant operation, and is necessary only in cases in which division of the soft parts is not enough to allow sufficient extension of the thigh on the pelvis.

At the knee a simple transverse division of the femur is made just above the condyles, allowing correction of both flexion and knock-knee at the same time. These operations, of course, have no effect upon the paralysis as such, but merely serve to place the limb in a position suitable for weight-bearing. After operation mechanical support is usually necessary.

(*e*) *Excision and Arthrodesis.*—The immediate object of operative procedures in the case of flail joints is to secure a stiff joint instead of one excessively movable, by opening and scraping out the synovial cavity or by removing the articular cartilages, or even taking a thin slice off the bones on each side of the joint and retaining the freshened surfaces in apposition, so that ankylosis may be favored and the limb may thus become of more use in locomotion.

An ankylosed joint is thus substituted for an unduly movable one, and supporting apparatus for that joint is not required. The joint is opened as for excision and a thin layer of bone removed with the joint cartilage. The technique of the operation and the after-treatment do not differ from that of excision.

From the results attending this operation, it may be stated that in very severe deformities and in patients of the poorer class the question of resection[1] of the joint surfaces of the knee and ankle is to be seriously

[1] Centralbl. f. Chirurg., 1887, No. 46.

considered[1] as a means of treatment in preference to the application of apparatus.

In other cases resection of joints[2] is to be considered on account of the extreme bony deformity which they present, as in severe paralytic knock-knee,[3] in which a stiff knee rather than a movable one is desired.[4] If the latter is preferable an osteotomy rather than an excision should be done, as the latter leaves a stiff joint. The deformity of knock-knee or flexion at the knee can, of course, be corrected by the plane of the bone section in excision.

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[1] Ap. M. Vance: Boston Med. and Surg. Journ., May 6th, 1886, p. 416.

[2] Franks and Stocker: Trans. of Acad. of Med. of Iceland, 1885; Lessor: Cent. f. Chir., 1879, No. 31, p. 497, and 1887, No. 46, p. 797.

[3] Kölliker: Deutsch. Zeit. f. Chir., xxiv., 591; Revue de Chir., 1886, vi., 890.

[4] Centralbl. f. Chirurg., 1888, No. 24.

CHAPTER XIV.

CEREBRAL PARALYSIS OF CHILDREN.

Symptoms.—Idiocy.—Etiology of cerebral paralysis.—Pathology of cerebral paralysis.—Diagnosis.—Differential diagnosis.—Prognosis.—Treatment.

The condition was first described by Little, von Heine, and Adams, but it is to later neurologists that we owe the understanding of the nature of the affection, which was formerly classed along with infantile paralysis.

It is known under the following names: Spastic paralysis, spastic hemiplegia, etc., Little's disease, tetanoid pseudo-paraplegia, permanent tetanus of the extremities, spastische Gliederstarre, etc.

The onset of cerebral paralysis may be prenatal. Cases may occur during birth, or they make their appearance after birth; in the latter case the majority occur in the first three years of life.

The affection is more common than was formerly supposed. At the Children's Hospital 185 cases of cerebral paralysis came to the Surgical Out-Patient Department, while 300 cases of infantile paralysis appeared during the same period. During a definite period at the Hospital for the Ruptured and Crippled in New York 91 children affected with cerebral paralysis applied for treatment, while 142 cases of spinal paralysis were seen.

Motor disturbances in children which are due to cerebral lesions are manifested clinically in one of three ways: (1) as a single hemiplegia; (2) as a diplegia; (3) as a paraplegia. Contractures, choreiform movements, mental impairment, aphasia, epilepsy, inco-ordination, etc., may be the accompaniments of any one of these forms.

The distribution of paralysis in 225 cases analyzed by Peterson and Sachs was as follows: Right hemiplegia, 81; left hemiplegia, 75; diplegia, 39; paraplegia, 30—total, 225.

Symptoms of Cerebral Paralysis in Cases Occurring After Birth.—The onset may resemble very closely that of infantile spinal paralysis; it often begins with an illness of some sort. Frequently paralysis develops in the course of an infectious disease, sometimes after an attack of what seems to be indigestion or a slight feverish attack, sometimes after a fall or blow on the head. Commonly the onset is marked by convulsions, as in 52 out of 90 of Osler's cases, 43 out of 88 in Wallenburg's, 30 out of 80 in Gaudard's, 12 out of 26 in the Children's Hospital series, and

"in more than half" of Gowers' 80 cases. Delirium or screaming spells may accompany the onset. Sometimes however, though very rarely, the disease develops suddenly in perfectly healthy children without any febrile or other disturbance, or it may develop insidiously without disturbance enough to attract attention. From the second year, for the first six or seven years of life, the liability very gradually diminishes; the number of cases, however, rising slightly at the time of the second dentition;[1] in this respect it offers a sharp contrast to infantile spinal paralysis.

When the paralysis is noticed, it is found to be most often hemiplegic in distribution. Monoplegia is rare. The face is paralyzed in a moderate proportion of all cases (twenty per cent according to Sachs), and the arm is always affected more severely than the leg and recovers more slowly. The facial paralysis ordinarily is not complete and does not affect the muscles that close the eyes. It disappears first of all the paralyses, and often recovery is complete. Strabismus is very common. The paralyzed side is powerless, but sensation is generally unimpaired; coldness and vascular sluggishness are present in some of the severer cases. The reflexes of the affected side are much increased from the first, a sign which is of the greatest assistance in diagnosis. As in the hemiplegia of adults, rigidity of the affected muscles comes on in about seventy-five per cent of all cases at a varying time after the onset of the paralysis. The rigidity, when present, is increased by any attempt to use the limb; it is excited by passive manipulation and it disappears during sleep, and usually under an anæsthetic. Post-hemiplegic movements follow in a certain proportion of cases.[2] Hemianopsia may be present.[3]

Aphasia accompanies probably a certain proportion of cases of cerebral paralysis, but it is often transitory.[4] It is always motor aphasia and may accompany either right or left hemiplegia.

Mental enfeeblement, varying from complete idiocy to simple backwardness, develops in a large proportion of all cases. In the 26 cases in the Children's Hospital series only 6 had what was classed as average intelligence, and one of these was aphasic and one stuttered very badly. Of the rest, 7 were idiotic, 8 feeble-minded, and 4 very backward, and Wallenburg in his 160 cases found 65 with serious mental defects. Sachs found idiocy present in 35 per cent of all diplegias and in 60 per cent of paraplegias, while it occurred in but 13 per cent of hemiplegias. Merklin calls attention to the fact that such children

[1] Wallenburg: Loc. cit.

[2] Richardson: Bost. Med. and Surg. Journ., May 20th, 1880; Hammond: "Dis. of Nerv. System," New York, 1886, p. 281; Sharkey: "Spasm in Chronic Nerve Dis.," London, 1886, p. 37; Knapp; Boston Med. and Surg. Jour., Nov. 22, 1888.

[3] Freud: "Cerebrale Diplegien." Vienna, 1892.

[4] Bernhardt: Virch. Archiv, Bd. 102.

as escape mental deterioration in childhood often develop psychoses later in life.[1]

Epileptic attacks appear in the paralyzed limbs and thence become generalized in one-quarter to one-half of all cases reported. Ordinarily they come on in two or three years after the paralysis, but they may be delayed, and ten or even thirty years may elapse sometimes[2]; on the other hand, they may begin within a few weeks of the onset.

The mind may, however, remain perfectly clear in spite of a severe hemiplegia, and no sign of mental deterioration may be present in the early or the late history of the disease.

To the later history of the affection belong the atrophy and contractions of the limbs. In hemiplegia the affected side rarely recovers en-

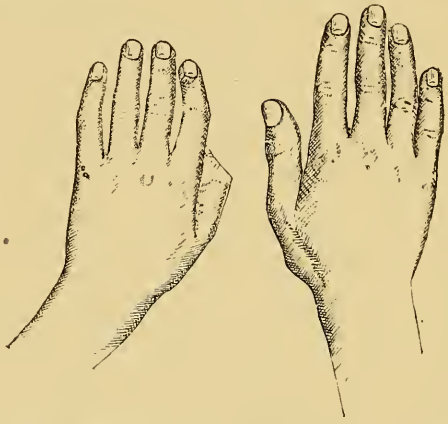

FIG. 470.—Atrophy of the Hand in a Case of Hemiplegia of Several Years' Duration. (Knapp.)

tirely, and often the growth of the bones is retarded. The muscular atrophy, as a rule, is not so great as in infantile spinal paralysis, but in certain cases the muscles waste very much. In severe cases there is marked arrest of growth in the bones. In the Children's Hospital series one case showed a shortening of two inches in the arm after the paralysis had lasted seventeen years, and three other cases of four, seven, and eight years' standing showed a shortening of one inch. This cannot be the atrophy of disuse,[3] but points to some trophic lesion. It has been questioned whether or not serious muscular atrophy does not mean spinal involvement. Hypertrophy of the paralyzed members has been reported.

The permanent contractions that come on are most noticeable in the arm, and as a rule are of one type in the arm and leg. In the former the

[1] Merklin: St. Petersburger med. Wochenschrift, 1887.

[2] Gowers: "Epilepsy," London, 1880.

[3] Forster: Jahrbuch f. Kinderheilkunde, N. F., 15, 261, 1880.

arm is held close to the side, the elbow is flexed strongly and firmly, the hand is flexed and the fingers are drawn into the palm, usually embracing the thumb. These contractions are very firm and resisting. The leg in bad cases is adducted and flexed at the hip, the hamstring muscles of the knee have contracted, and flexion of the knee has resulted, and the foot is in a position of talipes equino-varus or simple equinus. In other cases[1] only the finer movements of the hand may be lost, and the leg movements may be impaired only enough to cause a bad limp.

Post-Paralytic Disorders of Movement.—In certain cases of hemiplegia, single and double, a

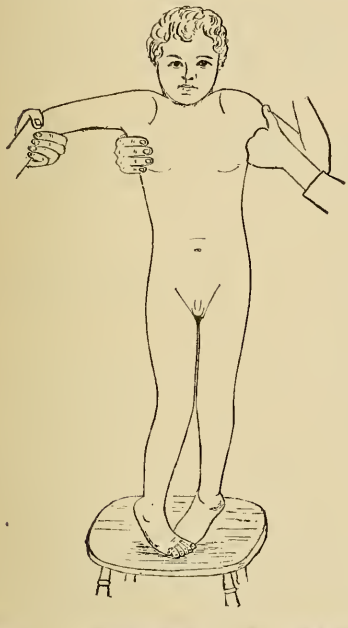

FIG. 471.—Standing Position in Spastic Paralysis.

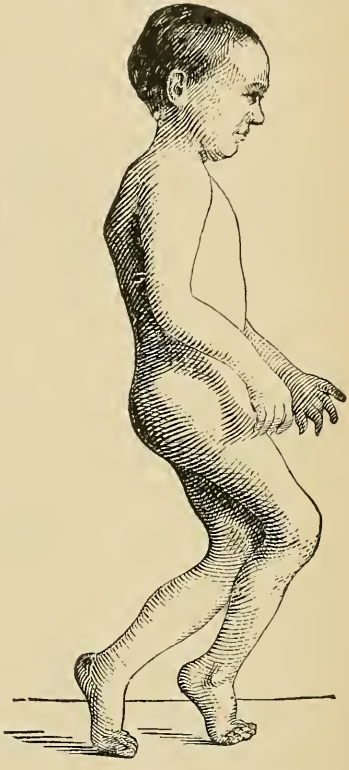

FIG. 472.—The Gait in Spastic Paraplegia.

disturbance of motion occurs at a later stage, which is spoken of under many different names, such as athetosis and chorea spastica; while what is called "congenital chorea" in many cases is the same affection.[2]

Gowers[3] has described a characteristic slow mobile spasm, which he speaks of as "mobile spasm." The paper of Knapp[4] deals in detail with the character of these movements.

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[1] Journ. of Nerv. and Mental Dis., August, 1887.

[2] Rau: Neurol. Centralblatt., 1887; Greidenberg: Archiv f. Psychiatrie, xvii., 131, 1886.

[3] Gowers: "Dis. of Nerv. Syst.," vol. ii., p. 79.

[4] Knapp: Loc. cit.

Spastic Condition of the Muscles.—At times the tonic spasm of the muscles becomes so much the most prominent feature of the case that it is spoken of as spastic paralysis rather than as hemiplegia, especially in diplegic and paraplegic cases. Spastic paralysis is a condition characterized by a persistent stiffness and constant spasm of the muscles of the legs and sometimes of the arms; the legs are straight and rigid, and the feet are extended, and when an attempt is made to walk the child stands on tiptoe, and often the spasm of the adductor muscles is so great that the legs are crossed. The walk is almost characteristic—a clinging gait, in which the feet are scraped along the floor with much effort and straining at every step, if indeed the spasm is not so great that walking at all is out of the question.

In general this affection is the result of a cerebral lesion and a descending degeneration of the lateral columns of the spinal cord. There are, however, a few rare cases in which there is reason to believe that the affection may be primarily spinal.

This grade of affection is in the majority of cases prenatal or caused at birth, and represents the result of a larger brain lesion than takes place in hemiplegia. For this reason, these children are for the most part feeble-minded or idiotic—as one might reasonably expect as the result of so extensive a brain lesion occurring at so early an age.

However, one not uncommonly sees children of more than average intelligence affected with spastic paraplegia, so that the existence of spastic paralysis is by no means evidence of mental inferiority.

Often these children have strabismus, a stupid, idiotic face, the saliva drips from the mouth, and the teeth decay very early.[1] Most often they walk in the manner described, but sometimes the muscular spasm is so great that the joints are so fixed as to be useless. In the milder cases the difficulty in walking lies in the fact that any effort to use the limbs increases the muscular spasm and tends to throw the leg into the position of extreme adduction, with extension of the foot and generally slight flexion of the knees with talipes equinus. It is often impossible to demonstrate the increased tendon reflexes either at the knee or at the ankle on account of the great stiffness of the legs, because the muscles are continually at their maximum of contraction. The electrical reaction in these and in the hemiplegia cases is unchanged.

In certain cases the spasm is so great that the patient is unable to stand alone. When supported, the thighs are adducted very closely and the toes pointed and crossed.

The children are apt to be uncleanly in their habits until they have reached the age of four or five years at least. The mental disability may

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[1] Alice Lollier: "De l'État de la Dentition chez les Enfants idiots et arrières," Paris, 1887.

be manifested in the milder cases by an excessive irritability and a disposition to do mischief and perhaps to destroy playthings wantonly. Furious outbursts of temper are not uncommon, while in the severer cases stupidity is the most prominent feature, and all the characteristics of idiocy are in many cases plainly developed.

The cases of cerebral paralysis in the Children's Hospital series were analyzed with regard to the relation of spastic paralysis of the legs and

FIG. 473.—Attitude in Idiocy.

hemiplegia. There were twenty-six hemiplegia cases and in nine of these patients spastic paralysis of both legs was also present.

It seems as if spastic paralysis of the legs were occasionally a sequel of simple hemiplegia coming on after some years.

Inco-ordination or Idiocy.—This condition may be the accompaniment of cerebral palsy or it may be the result of other causes.

The classification of Sachs is as follows:

1. Hereditary idiocy { (*a*) congenital. (*b*) developmental.
2. Acquired idiocy { after traumatism. after convulsions. after infectious diseases.
3. Myxœdematous idiocy.

The only excuse for its introduction here is the very close outward resemblance that these conditions present on superficial examination to the

spastic cases already considered; but definite paralysis and spastic rigidity of the muscles are absent, and idiocy obscures everything. If patients are seen seated, the stupid cross-eyed look, the drooping head, and the drooling are exactly what is seen in the severe mental enfeeblement of spastic paralysis or hemiplegia. But put the child on his feet and the difference is at once evident. Either his muscles are so lax that he will be unable to bear his weight at all, or he will stand holding his parent's hands with his feet wide apart, his knees bent, and his trunk leaning forward. The whole body sways to and fro with an oscillating movement, and the sense of equilibrium seems almost wanting; if he is let alone, he walks in a staggering, uncertain way, with many falls. From this the condition grades off to a disability so great that the child cannot even sit up; when it is propped up the head lops on to one shoulder, the vertebral column fails to support the trunk and bends to a marked degree, and every muscle seems limp and useless. There is no suspicion of muscular rigidity or localized paralysis.

Sensory disturbances are not uncommon, and often a pin can be thrust through the skin without pain. Nearly all these children have strabismus, often with a large head and prow-shaped forehead. The reflexes are sometimes normal and sometimes increased, while the legs are generally flabby and cool, and the hands and feet often undeveloped. Every grade of the condition is seen from that described above to complete helplessness.

Etiology.

The etiology of prenatal cases of cerebral palsy is obscure. Such cases occur in neurotic and epileptic families. Traumatism to the mother during her pregnancy, severe illness of the mother, severe fright, and hereditary syphilis are among the causes. The etiology of cases dating from birth is better formulated. Asphyxia at birth, prolonged labors, and instrumental deliveries are frequent causes.

Weber, however, made 161 autopsies of new-born children, and in 81 cases in which the spinal canal and head were opened, 33 times there was extravasation of blood from the spinal and cerebral meninges. The influence of difficult labor as a cause of cerebral paralysis seems to have been somewhat overestimated.[1] Of Mr. Little's cases a large proportion are abnormal only in the occurrence of phenomena which are of little interest, *e.g.*, three cases are considered abnormal because the cord was wound around the child's neck. In the 33 cases of cerebral paralysis in which the labor was noted in the Children's Hospital series, 17 were born by an easy labor according to the mother's own account. The forceps, however, occasionally causes so serious an injury that a depression of the

[1] "Mental Affections of Childhood and Youth," London, 1887, p. 44.

skull is noted years afterward on the side opposite to the hemiplegia. There were 2 cases of hemiplegia in the Children's Hospital series in which a depression in the skull was evident four and eight years after the beginning of the paralysis. Wallenburg, in his 160 cases, assigned difficult labor as a cause in only 6 cases and does not mention injury from the use of forceps.[1] A large number of these children are born prematurely, as in 28 out of 49 of Little's cases, and at other times asphyxia neonatorum seems to be the active cause.[2]

In cerebral paralysis acquired after birth there are certain well formulated causes. Acute infectious diseases play their part, cases having occurred after measles, scarlatina, typhoid fever, smallpox, tonsillitis, pneumonia, pertussis, cerebrospinal meningitis, gastro-enteritis, mumps, diphtheria, dysentery, typhus fever, and syphilis. Fright and trauma are two other accepted causes.[3]

In a large number of cases the disease seems to affect perfectly healthy children without any assignable cause. The indigestion attacks, the fever, and the convulsions attending the onset cannot fairly be assigned as causes. The disease is about evenly divided between the sexes.

Pathology.

The pathological condition is much the same in hemiplegia, diplegia, and paraplegia. These conditions in general are due to embolism or hemorrhage, and the resulting retardation of growth of the affected portion of the brain, together with the secondary changes in the spinal cord. Autopsies made later in the disease show pathological changes which are more extensive and less definite in their character. Wasting and sclerosis of a greater or less part of the brain and the condition known as porencephalus are what one finds in these later cases. These seem to be the late results of the destructive change mentioned above, which have occurred in a growing brain and have retarded its growth and have produced an extensive scar formation in the place of cerebral tissue.

Porencephalus occurs as a loss of substance in the form of cavities or cysts, situated at the surface of the brain and going more or less deeply

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[1] Phila. Med. News, 1887, ii. Paper by Dr. Parvin: American Journ. Med. Sci., 1875; Sinkler: Med. News, 1885, vol. i.

[2] McNutt: Am. Journ. of Obst., 1885; Parrot: "Clinique des Nouveau-nés," Paris, 1877.

[3] Obstet. Trans., London, vol. xxvi.; Boston Med. and Surg. Journal, June 28th, 1888; see also three cases similar in Osler's series; Wallenburg, Gowers, and Gaudard: Loc. cit.; Marie: Prog. Méd., No. 36; Richardière: "Étude sur le Sclérose Encéph. de l'Enf.," etc., Thèse de Paris; Jendrássik and Marie: Arch. de Phys. Norm. et Path., v., 51, 1885; Osler: Phila. Med. News, July 14th, 1888; Abercrombie: St. Barth. Hosp. Rep., xvi., p. 35, and Brit. Med. Journ., June 18th, 1887.

into it; it is in all cases the motor region which is affected. This condition of porencephalus may be of greater or less extent and unilateral or bilateral. If either porencephalus or sclerosis is unilateral, hemiplegia

FIG. 474.—Meningeal Hemorrhage at Birth. Death on the twenty-second day. (McNutt.)

results; if the lesion is bilateral, double hemiplegia or spastic paraplegia is the clinical manifestation. These lesions represent merely the late stages of a process originally a hemorrhage, an embolism, or a localized encephalitis.

The pathology of the condition is, in short, a lesion of the motor tract of the brain with consequent atrophy and retarded development of

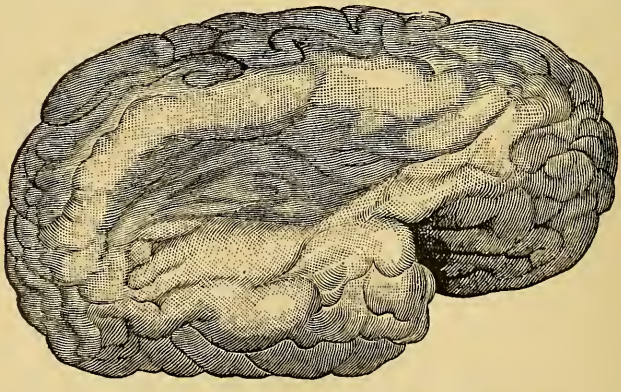

FIG. 475.—Cyst Formed by Softening of Brain Substance, Secondary to Obstruction of the Middle Cerebral Artery. Child of nineteen months. (Sachs.)

the affected portion, and descending degeneration of the pyramidal tracts and lateral columns of the cord. From the extensive atrophy found

in young children at autopsy, it seems that unquestionably sometimes the disease originates in defective development of the nervous centres, especially the pyramidal tracts, rather than in an acute cerebral hemorrhage or embolism.

Of 78 autopsies analyzed by Sachs and Peterson the condition was as follows:

Atrophy, sclerosis, and cysts,	40
Porencephalus,	2
Hemorrhage,	23
Embolism,	7
Thrombosis,	5
Tubercle,	1
	78

Osler in 90 brains found a vascular lesion in 16 only, 7 due to hemorrhage and 9 to embolism.

FIG. 476.—Section through Portion of Motor Cortex, Removed in Operation for Localized Epilepsy with Left Hemiplegia. Boy of twelve years. Van Gieson stain. *P*, The pia much thickened, dips between folds of cortex; *B*, increased number of thickened small arteries above; to right a large artery with thickened walls; *H*, a recent clot. (Sachs.)

The theory of Strümpell that the condition was due to a polioencephalitis similar to poliomyelitis has not received confirmation nor the support of modern neurologists.

[1] Archiv f. Psych., Bd. xvii.; Archives de Physiol., 3e série, tome iv., 1884; Sharkey: Quoted by Osler, loc. cit., p. 143; Blocq: "Les Contractures." Paris, 1888.

Cerebral hemorrhages in children differ from those in adults in that the former occur in and near the cortex while the latter most often occur in the vicinity of the internal capsule.

Heart disease, rheumatism, scarlet fever are the conditions which might lead one to suspect embolism rather than hemorrhage.

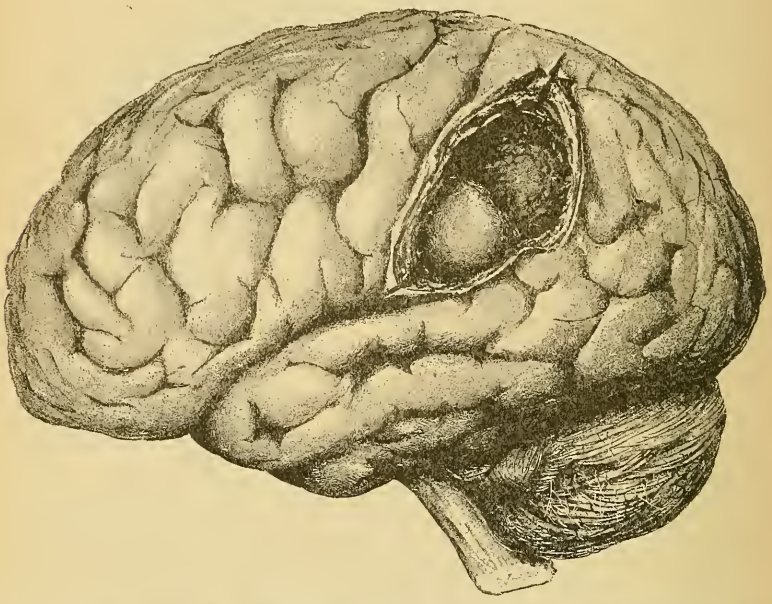

FIG. 477.—Old Hemorrhagic Cyst. Cyst wall cut to expose tumor underneath. Right hemiplegia at age of six and a half years. Death two years later. (Sachs.)

Osler[1] summed up the possible causes of infantile hemiplegia as follows:

(1) Hemorrhage occurring during violent convulsions or during a paroxysm of whooping-cough[2] (or at birth).

(2) Post-febrile processes, (*a*) embolic,[3] (*b*) endo- and peri-arterial changes,[4] (*c*) encephalitis.

(3) Thrombosis of cerebral veins.[5]

There seems reason to believe that all of these causes at times have an influence singly or together in producing cerebral paralysis.

To enter upon a discussion of the pathological condition in the cases of inco-ordination spoken of above would be to introduce the very extensive subject of the pathology of idiocy.[6]

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[1] Osler: Med. News, Phila., August 11th, 1888, p. 143.

[2] West: London Med. Press and Circ., 1887.

[3] Landouzy and Siredey: Rev. de Méd., 1885.

[4] Jendrássik and Marie: Arch. für Phys., 1885.

[5] Gowers and Handford: Brit. Med. Journal, 1887, i., 1098.

[6] Cotard: Thèse de Paris, 1868; Seibert: Arch. of Pediatrics, March, 1888, 168;

Diagnosis.

The diagnostic signs of hemiplegia in the child are as follows: a motor paralysis of one or both sides of the body and often one side of the face, while no loss of sensation is present. The reflexes of the affected side are increased and mental impairment is common.

When spastic paraplegia is present it is characterized by tonic contraction of the muscles which yields to steady resistance. The galvanic

Fig. 478.

Fig. 479.

Figs. 478 and 479.—Spastic Paralysis.

reaction is normal. At times the muscular rigidity is so excessive that the exaggerated knee jerk and ankle clonus cannot be obtained. In estimating the child's mental condition, no weight whatever can be attached to the parents' account of the patient's capacity.

The differentiation of cerebral paralysis and infantile spinal paralysis has been dealt with.

Beach: Am. Jour. Ment. Sci., June, 1883, and April, 1881; Bunhuer: Arch. f. Psych., xii., 3; Tambarini: Revist. Sperim., vi., 285; Seibert: Loc. cit.

Obstetrical paralysis[1] might be mistaken for cerebral lesions, but a careful examination would determine the paralysis to be limited to the distribution of some especial nerve or group of nerves.[2] It occurs in the distribution of the facial nerve after the use of the forceps, but it may occur in one of the extremities in consequence of the stretching of the nerve trunks in the manual extraction of the child's body. It often occurs in the shoulder.

Cerebral tumors may cause the symptoms of hemiplegia, and a diagnosis of this condition from the lesions generally causing paralysis would ordinarily be impossible.[3] Tumors of the pons or cerebellum would cause symptoms of bilateral rigidity (spastic paraplegia) if they compressed the motor tracts.

Pseudo-hypertrophic paralysis, the pseudo-paralysis of rickets, syphilis of the spinal cord, and hereditary spastic paralysis are possible sources of an error of diagnosis in obscure cases. Certain cases of chorea prove on investigation to have their origin in a slight cerebral paralysis. The same may be said of epilepsy.

There is no diagnostic criterion by which the recognition of the miscellaneous cases of idiocy or inco-ordination may be surely made, so that the diagnosis of inco-ordination or idiocy is often attended with much difficulty, especially in young children, when inability to walk is the only definite symptom. Such a condition may result from rickets, from feebleness, from simple backwardness, and sometimes from paralysis due to unnoticed Pott's disease. Under these circumstances one would give much weight in the diagnosis of idiocy to the child's expression, the size of the head, the presence of strabismus, and especially an oscillating, rhythmical movement of the head or whole body as pointing to some cerebral insufficiency. Later in life the condition is only too apparent.

Prognosis.

The prognosis in these cases should be most guarded. In hemiplegia there are two things to be said, the child will probably live and the paralysis will probably improve somewhat. The unfavorable things which are to be feared, in general, are more likely to come in the earlier cases of paralysis than in those that occur later in life. These are: mental enfeeblement, a certain amount of deformity from retarded growth of the paralyzed side, and epilepsy in about half the cases, per-

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[1] Duchenne: "Traité de l'Électrisation Localisée," 3d ed.

[2] Nadaud: "Des Par. Obstétricales des Nouveau-nés." Paris, 1872.

[3] Seeligmüller: Jahrb. f. Khde., Bd. xiii.; Osler: Am. Journ. Med. Sci., 1885; Sharkey: "Spasm in Chronic Nerve Disease," London, 1886; Onimus: Rev. mens. des Mal. de l'Enfance, 1883; Lannois: France médicale, 1884; Limard: Thèse de Paris, 1884, No. 85.

haps not making its appearance until the age of puberty. Spastic paralysis of both legs is to be feared as a later sequel to the hemiplegia.

On the other hand, in many instances in which complete helplessness exists in infancy, marked improvement to a condition of comparative activity is sometimes noticed.

In congenital cases the occurrence of convulsions in the early weeks of life indicates generally a severe lesion. If the mental condition continues dull idiocy is to be feared. If after a few months the convulsions diminish and the child uses its legs fairly and shows interest in its surroundings, the prognosis is better. Diplegia and paraplegia, it must be remembered, are more often associated with epilepsy and idiocy than is hemiplegia.

In acquired cases a tendency toward recovery in movement and speech after a few weeks is encouraging; the absence of such tendency is unfavorable. Epilepsy may not occur at once, and it must be remembered that about half the cases of hemiplegia develop it sooner or later. The occurrence of convulsions in a child with any form of cerebral paralysis is unfavorable.

With regard to spastic paraplegia, it is safe to assert in most cases that the child will improve in the use of the legs; most children learn to walk at the age of five or six and to talk imperfectly. The general tendency is toward improvement in walking and talking for many years, although it must be borne in mind that the final result in well-marked cases can rarely be other than distressing. Mental enfeeblement is generally present from the first, when it is present at all, but it may become much more evident as the years go on when the demands upon the intellect become more complicated and exacting.

The general resistance of such children is not very good, they are more liable than other children to fall victims to general diseases, and their inability to go about freely renders them more susceptible to illness. As a rule, they are not long-lived, but there is no immediate liability to any especial disease, simply a slightly impaired vitality. No question is more often asked than this one about the child's prospect of long life.

The cases of inco-ordination or idiocy do not show any tendency to spontaneous improvement. Sometimes they improve, and sometimes they grow worse, but oftenest they seem to remain in very much the same condition.

Treatment.

During the onset of the disease, in those rare cases in which the diagnosis of a destructive cerebral lesion is made so early, the treatment should be the same that is ordinarily advisable in any convulsive attack.

In the great majority of cases the nature of the trouble is not recognized until the acute symptoms have passed off and the paralysis has

become well established. As in anterior poliomyelitis the structural harm has been done and no treatment addressed to the centres can accomplish very much. The aim must be to keep the paralyzed limb as far as possible from trophic changes and to stimulate the muscles to recover as far as possible by carefully caring for their condition. Electricity should not be applied to the brain. The proper use of electricity is in its stimulation of the muscles. Undoubtedly benefit results from a careful course of this treatment, but it must be long continued and it is not essential to improvement, for many cases do perfectly well without any use of electricity. Galvanism of the spine with an ascending or descending current is deemed of use in cases of spastic paralysis.

Of equal or greater importance is a systematic and persistent course of rubbing and manipulation of the paralyzed limbs. In spastic paralysis, persistent manipulations with strong flexion and extension of the diseased limbs may prove of great benefit in preventing a disabling rigidity and in maintaining a healthy condition of the muscles. The knees and hips should be forcibly flexed several times a day and the feet bent up beyond a right angle if any reasonable degree of force will accomplish it.

In spastic paralysis it is at times possible to accomplish much by muscular training and exercise. More could be done in this way were it not for the mental inability of so many of these patients, which makes it impossible for them to co-operate to any extent in such treatment. But in those cases in which the mind is bright and active, the patient can be trained to use the limbs to much better advantage than he has been doing, just as a person who stutters can be improved by systematic and repeated exercises. The muscles which are most strongly contracted are the thigh adductors and the calf muscles. Such a patient should be given exercises calculated to develop the abductor muscles and the flexors of the foot, which by increased power will in a measure counterbalance the muscles which are so powerful. The patient should lie on the back on a hard table, and should separate the legs as far as possible at first without being touched, and then against slight resistance. The legs in the extended position should be rotated outward, while the heels are kept together. In walking the patient should be cautioned to go very slowly, to lift each foot well off of the ground and to turn out the toes with much care. In connection with massage and rubbing, this method of treatment is capable of accomplishing a decided change in the method of walking, and while the walk still is stiff and unsteady it has lost the characteristic scraping and dragging of the spastic gait. Such patients walk with much less fatigue than before and feel much more steady upon their feet.

The mental training of such children is a matter of the greatest importance in order to render as active as possible the remaining functions of the brain. One has only to visit an institution adapted to the teach-

ing of such children to appreciate the great advantages that such special teaching offers over that of the ordinary school training. The disappearance of the aphasia is aided by systematic training and it always proves more tractable than in the adult. The epileptic attacks are not likely to be helped by medicinal treatment, on account of the nature of the lesion causing them.

Apparatus is suited to the treatment of the milder deformities only. Talipes equino-varus of a mild degree may be temporarily corrected by a proper appliance, such as a Taylor shoe. The paralysis is commonly so incomplete that the muscles furnish sufficient support to the affected limb, but owing to the increased reflex excitability and to imperfect motor impulses the muscles are in a state of spasm and of uselessness from the distorted position. Children with this affection are brought by parents to the surgeon with the request that braces be applied to make the child walk and that spinal supports be furnished. In general the deformities are to be treated as in infantile paralysis, but the muscles cannot be stretched to an extent permitting correction of the deformity. The deformity returns immediately on removal of the appliance; so that, apart from the temporary rectification, apparatus is of little advantage in cerebral paralysis. Retentive apparatus, however, is of use in retaining the limbs in proper position after operation.

Operative Treatment.

Post-hemiplegic movements are at times relieved by placing the member at rest for some weeks or months under restraint. For example, an arm may be done up in a snug plaster bandage. Clinical evidence has proved that tenotomy, especially of the tendo Achillis, in this class of cases is of much use.[1]

The writers would unhesitatingly claim great benefit for the operation in suitable cases. The orthopedic surgeon will meet a certain number of cases of this class with pronounced equinus deformity of one or both feet. Locomotion is difficult for the reason that it is impossible for the patient to bear the weight upon the whole sole of the foot. This increased difficulty is sometimes sufficient to deter the patient from efforts at locomotion and always adds to the unsteadiness of gait. If tenotomy of the tendo Achillis is done, the contraction ceases, and though the strength of the muscle is not lost in a number of cases which have been watched by the writers for several years, there is tendency to a reappearance of the equinus deformity.

In a few instances of this sort a practical cure has been gained by tenotomy. This treatment is especially suited to those cases in which

[1] W. N. Bullard: Boston Med. and Surg. Journ., February 16th, 1888.

there is no mental disturbance and in which the upper extremities are not affected, but it is not by any means confined to these cases.

Division of the hamstring muscles by open incision should be done when they are sufficiently contracted to prevent the full extension of the knee. This operation is preferable to tenotomy because it offers a better chance to divide contracted tissues other than tendons.

FIG. 480.—Spastic Paralysis before Operation.

In the severer cases division of the adductor tendons is also of benefit, as the adductor spasm often causes the knees to knock together in walking and is a serious obstacle in progression. The division in mild cases may be by subcutaneous tenotomy, but severe cases are best treated by open incision.

The writers are in favor of free division of all contracted tendons or muscles if necessary in spastic paralysis. Their personal experience has led them to regard the operation as a most useful one, and they have never seen any bad results from it. Even in adults the operation is permissible and useful. If it is not done thoroughly and all contracting tissues are not divided, relapse may occur. If such is the case a second operation should be done.

Eulenburg[1] has attempted tendon anastomosis in one case of spastic equino-varus with a favorable result. The tendo Achillis was split lengthwise and cut, the outer half was attached to the peroneal tendons and the inner half was left free.

Tenotomy or myotomy may also be useful in contraction of the hand and arm in cases of spastic hemiplegia. When such operations are undertaken they should be thorough and all contracted structures divided which offer an impediment to the proper use of the limb.

In the severer cases open incision is preferable to a subcutaneous tenotomy.

After the operation the limb and foot should be immediately corrected and fixed in an over-corrected position, until the tendon has united and

[1] Deutsch. med. Wochenschrift, April 7th, 1898.

the wound has healed. The writers do not attempt to offer any theoretical explanation of the benefit gained, but they simply present the marked improvement to be often obtained by surgical interference, which is much greater than can be gained by the use of any appliance or by massage or electricity. After tenotomy, correction appliances should be used for a few months to steady the limb, but ultimately may be discontinued and permanently discarded.

FIG. 481.—Spastic Paralysis after Operation.

The possibility of the relief of epilepsy and the other symptoms of cerebral paralysis by surgical interference at the seat of the brain lesion has not been overlooked. The success reached by Horsley and others in the cure of epilepsy by the removal of tumors from the motor area of the brain has led to attempts to relieve the epileptic or spastic condition in these cases by a removal of the lesion in the cortex.

With regard to the relief of these conditions by operative measures the nature of the lesions should be borne in mind, which are, as we have seen: (1) foci of destroyed brain tissue due to hemorrhage, embolism, or perhaps thrombosis; (2) sclerosis; (3) porencephalus. In every case a defect of tissue; there is generally nothing to be removed; to make the hole in the brain bigger is not likely to help matters; the existence of descending degeneration of the cord in cases of long standing is another obstacle to successful relief. The opening of cysts may be attended by improvement when these occur.

But the practical results of brain operations in this class of cases have

not been on the whole encouraging. Such cases operated on for the relief of epilepsy are reported by Horsley, Oppenheim (quoted by Freud), Gerster, Wyeth, Keen, Weir, Park, Angell, Starr, and others.

In exceptional cases, such as the glioma reported by Osler, surgical interference would probably have been of much benefit. In general, however, in the cases of long standing, very little can be expected of surgical measures, although an exploratory trephining might lead to good results.

When balanitis and genital irritation under the foreskin are present, as is shown by painful micturition and frequent erections, circumcision is often needed; but when a congenital cerebral defect is present, as is the case in most of the well-marked instances of spastic paralysis, circumcision is useless so far as it is to be regarded as a curative measure.

Summary.

The treatment of hemiplegia in the early stage is, in a word, rubbing and exercise to keep the muscles in good condition, and mental training; when deformity of the affected limb comes on, it should be corrected by apparatus or tenotomy. Severe spastic paralysis may be helped by cutting resistant structures when the limbs are deformed, but the distortion is not likely to be improved by purely mechanical treatment. Rubbing and gymnastics are of much benefit, and should be faithfully tried.

CHAPTER XV.

PSEUDO-HYPERTROPHIC AND OTHER PARALYSES.

Pseudo-hypertrophic muscular paralysis.—Progressive muscular atrophy.—Hereditary ataxia.—Obstetrical paralysis.

THERE are certain motor disturbances affecting children which come under the notice of the orthopedic surgeon so frequently that a brief mention of their characteristics deserves a place in this book. They cannot, of course, be considered in detail, but are simply presented in their practical surgical and therapeutic aspect. These affections are:

I. Pseudo-hypertrophic muscular paralysis. Progressive muscular atrophy.

II. Hereditary locomotor ataxia.

I. PSEUDO-HYPERTROPHIC MUSCULAR PARALYSIS.

Definition.—Pseudo-hypertrophic muscular paralysis is an affection of the muscular system characterized by a diminution or loss of the functional energy of certain muscles, and an abnormal increase in their size, which, together with diminution in the size of other muscles, is pathognomonic. The affection is also known as muscular pseudo-hypertrophy, lipomatous muscular atrophy, diffuse muscular lipomatosis, myopachynsis lipomatosa (Uhde); Paralysie myosclérosique, paralysie musculaire pseudo-hypertrophique. Modern classification places the affection among the progressive muscular atrophies.

Etiology.—The etiology of the affection is obscure. The disease develops during childhood in nearly all the cases, but in exceptional instances its appearance is delayed until the age of eighteen or twenty years. It affects males more commonly than females in about the proportion of four or five males to one female. The disease is more apt to occur in family groups than in isolated cases, and the hereditary element is marked.

Pathology.—The pathological condition consists in the overgrowth of the connective tissue in the muscles and the wasting of the muscular substance proper, while a deposit of fat takes place to a greater or less extent. No constant or characteristic pathological condition is found in

the spinal cord,[1] although various changes have been described, and the condition is at present still regarded as a primary affection.[2]

Symptoms.—The first symptoms to attract attention to the child's condition are muscular feebleness and peculiarity of gait. These generally precede any noticeable enlargement of the muscles. Such children

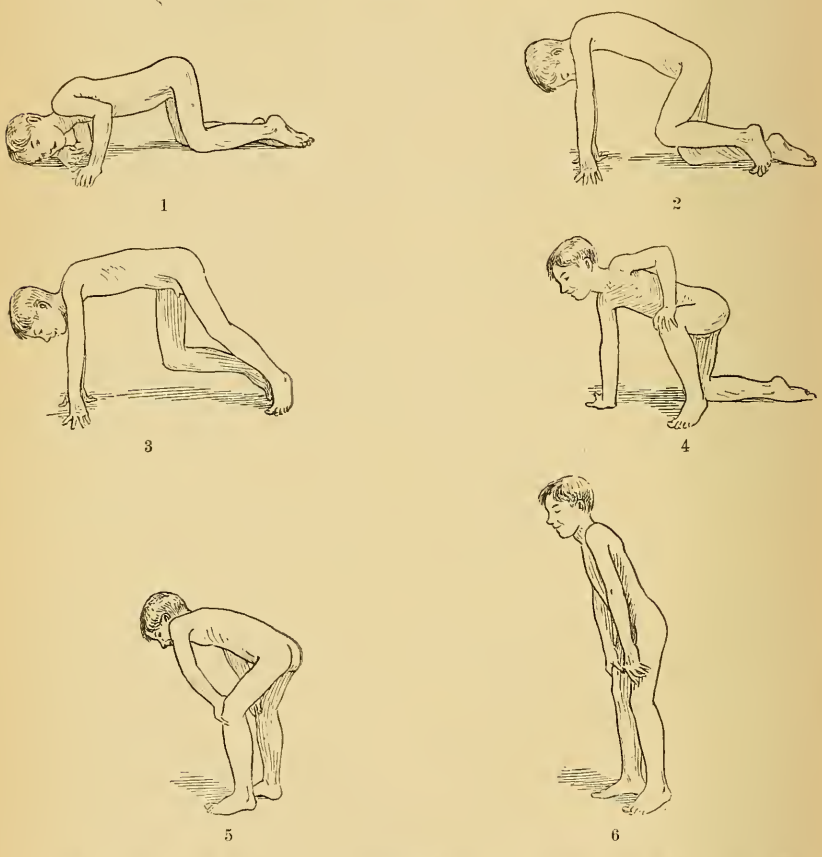

FIG. 482.—Method of Rising from Prone Position in Pseudo-Hypertrophic Paralysis. (From series of photographs.)

tire very easily in walking and they have especial difficulty in going up and down stairs. They fall often and in rising from the ground they adopt a procedure which is one of the most characteristic features of the disease. Inasmuch as on account of muscular weakness they cannot straighten the back or extend the knees without assistance, they rise

[1] Med. Chir. Trans., lvii., p. 247, also Barth: Arch. f. Khde., xii., 1871, 121; Eulenburg and Cohnheim: Verhandlung der Berl. med. Gesellschaft, 1866, p. 191; Lancet, 1881, ii., 660; Byrom Bramwell: "Diseases of the Sp. Cord," Edin., 1882; Pekelharing: Virch. Archiv, lxxxix., 1882, p. 228; Sachs: Loc. cit., p. 431.

[2] Jacoby: Am. Journal Nerv. and Mental Disease, 1888.

from the ground in the manner shown in Fig. 482, using the muscles of the arms to accomplish what the leg and back muscles cannot do.

These children tend to walk with legs apart, and at times an awkward gait and a tendency to fall are for a long period the only symptoms of the affection.

Such patients learn to walk late and depend much in their progress upon the assistance afforded by the furniture, upon which they lean heavily. In kneeling on the hands and knees at times there may be noticed a characteristic saddle-shaped depression of the back, which is

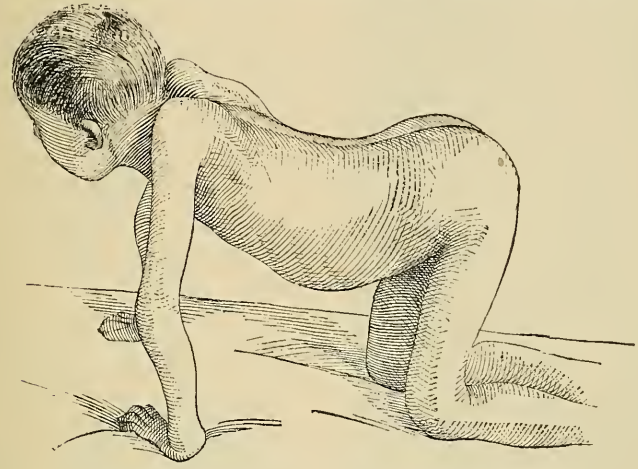

FIG. 483.—Saddleback Deformity in Muscular Pseudo-hypertrophy.

due to the weakness of the erector spinæ muscles. This is not an early accompaniment of the disease, but is a characteristic of the late stage when much lordosis is also present in standing.

In walking these children throw the centre of gravity of the body well over each leg in turn as it supports the body weight. In this way they save muscular effort. The result is a waddle more or less marked. They may stand with marked lordosis of the lumbar spine, chiefly due to a weakness of the lumbar muscles. The lordosis disappears when the patient sits down and a bowing backward of the whole vertebral column takes its place.

Mental enfeeblement is associated with the disease in many cases. The enlargement of the muscles is usually most marked in the calves of the legs. On this account the parents generally feel no anxiety because the child walks late or feebly, inasmuch as the development of the legs seems so remarkably good.

The affected muscles are hard and resistant to the touch, but at times the sensation in handling them is like that of a fatty tumor.

Atrophy of some of the muscles of the upper extremity is apt to be

present. The scapular muscles, the serrati, the latissimus dorsi, and the pectoralis major are often wasted.

Talipes equinus and flexion of the knees and hips may occur from muscular contraction. Lateral curvature of the spine may follow, and at other times a permanent flexion of the spine occurs from weakness of the erector spinæ muscles, and the child sits bowed forward. But these deformities mark only the late stage of the affection, which is more often characterized by a helplessness more or less complete.

Neither the reflexes nor the electrical reactions are modified in any degree until the muscles have

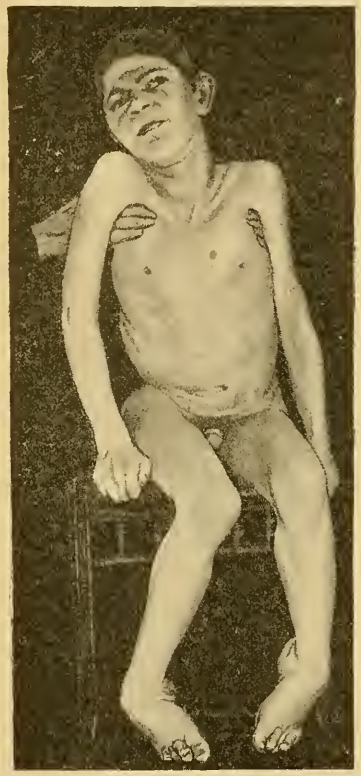

FIG. 484.—Late Stage of Pseudo-hypertrophic Paralysis, with Talipes Equino-Varus. (Sachs.)

FIG. 485.—Late Stage of Pseudo-hypertrophy. (Gowers.)

reached a marked stage of atrophy. Then they are diminished in proportion to the muscular wasting and finally they are lost. The reaction of degeneration is not present. Very often the skin over the affected limb is mottled and subject to vascular changes, indicating some vasomotor disturbance.

Diagnosis.—In well-defined cases the affection in its later stages is not likely to be mistaken for anything else. The peculiar gait with the feet wide apart and a reckless disregard of falls, the characteristic method of rising from the floor, the age of the patient, and the progressive character of the disease all suggest this affection. If examination shows enlargement of the calf muscles and normal or diminished reflexes the

diagnosis may be considered as established. Yet of even greater diagnostic importance than the enlargement of the calf muscles is the combination of enlargement of the infraspinatus and wasting of the latissimus dorsi and pectoralis major muscles—a state of affairs to which great diagnostic importance is to be attached.

The gait in early hypertrophic paralysis, and that in idiocy, spastic paralysis, in the paralysis of rickets and Pott's disease, and in simple weakness have very much in common.

Prognosis.—The prognosis is as unfavorable as possible. Recovery is all but unknown,[1] and arrest of the disease is very rare.[2]

The course of the disease is essentially chronic. The earliest stage is made manifest by muscular feebleness, and passes on to a stage in which hypertrophy of the muscles becomes evident. This stage is progressive and at the end of it the pseudo-hypertrophy reaches its maximum and the disease becomes stationary and remains so for two or three or perhaps several years. Then comes a time of increasing feebleness and extension of the paralysis. The muscles waste and the power of movement is lost in the legs and arms. In this deplorable condition the patient may live on until death comes from increasing exhaustion or some intercurrent disease.

Treatment.—It is practically hopeless from the time that the diagnosis is made, and there is no reason to believe that drugs have had any effect in retarding its progress. Electricity is sometimes of benefit in connection with other treatment.

There is, however, one rational mode of treatment in systematic muscular exercise and gymnastics, calculated, as in infantile paralysis, to keep the remaining muscles in the best possible state of nutrition and to ward off the permanent contractures.

Tenotomy is of use as soon as the heels are drawn up. Often walking may become impossible, chiefly on that account, and division of the tendo Achillis on both sides may restore for a time the power of walking; also tenotomy of the hamstring tendons at the knee may be indicated in severe cases.

Progressive Muscular Atrophy.

Progressive muscular atrophy is an affection characterized by a wasting of the voluntary muscles, and a consequent diminution in their power, which pursues a chronic course and attacks successively individual muscles and groups of muscles.

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[1] Duchenne: Arch. gén. de Méd., 1868, i., pp. 5 and 6.

[2] Donkin: "Note on a case of Pseudo-Hypertrophic Paralysis, Recovery," Brit. Med. Journal, April 15th, 1882.

Etiology.—In muscular atrophy as it occurs in children, the only cause assignable is a congenital tendency, often inherited. But at times isolated cases are met, and in adults other causes are to be taken into account.

Males are more often affected than females, and the time of onset of the disease is most variable; it may begin as early in life as at the age of three years or as late as sixty, but its development in advanced life is rare.

Progressive muscular atrophy has, since the days of Aran and Duchenne, been subdivided into different types.

(1) In the Aran-Duchenne type the atrophy begins oftenest in the small muscles of the hand, spreads to the forearm and perhaps the shoulders and back. It may begin in the muscles of the thighs. The atrophied muscles show fibrillary contractions, and the reaction of degeneration is present.

The affection has a pathology and is of spinal origin. The changes found are a sclerotic and pigmentary atrophy of the ganglion cells of the anterior cornua, an inflammatory condition of the neuroglia, and cellular proliferation. The anterior nerve roots are affected secondarily.

(2) The hereditary form is of the same general type as the preceding. It is very unusual and may occur in more than one member of a family.

(3) The peroneal form or leg type of progressive muscular atrophy affects in most cases the lower extremities. The extensor muscles of the toes are first affected, then the small muscles of the feet, and finally the entire leg. Talipes equinus or equino-varus is a common result.

The development of double club-foot with progressive wasting of the lower extremities is very suggestive of this type of the affection. It may affect the upper extremities first and then the lower.

Sensory changes are generally present. The reflexes in the lower extremities may be diminished or lost if the disease is sufficiently advanced. The electrical reactions, as a rule, are altered both quantitatively and qualitatively. Two cases of club-foot occurring in this type were successfully operated on by Gibney.[1]

The changes in the muscles consist in atrophy of the fibres, a loss of transverse striation, and a proliferation of the nuclei. There are present degenerations of the nerves, but changes of importance in the spinal cord have not been established.

The two remaining types along with pseudo-hypertrophic paralysis are to be classed as primary myopathies or primary muscular dystrophies in that they are not associated with demonstrable lesions in the spinal cord.

(4) Erb's type. The juvenile form of progressive muscular atrophy

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[1] Sachs: Loc. cit., p. 413.

is very rare and is characterized by progressive wasting of certain groups of muscles. These are the muscles of the shoulder girdle, the upper arm, the pelvic girdle, the thigh, and the back. The forearm and leg muscles remain, for a long time at least, intact. There are no fibrillary contractions, no reaction of degeneration, and no sensory disturbances.

(5) The Landouzy-Dejerine type or the facio-scapulo-humeral variety occurs at times in children. The muscles of the face are first affected and the atrophy spreads to the shoulder and arm muscles. In exceptional cases this type may begin in the arms or legs. The reaction of degeneration and fibrillary twitching are never present.

Treatment.—The medical treatment of all these affections is hopeless. When muscular contractions occur tendons should be cut and deformities rectified. Rest to the atrophied muscles, massage, and electricity are useful.

II. Hereditary Ataxia.

Hereditary ataxia deserves mention as a serious motor disorder which is sometimes met in children. It is dependent upon a family predisposition, but is not often directly inherited, but more commonly appears in several members of one generation. Hence the name of family ataxia. It is also known as Friedreich's disease. Other names are, hereditary ataxic paraplegia, and degenerative ataxia. The cases are rare.

Etiology.—Aside from the influence of a congenital tendency the cause of the disease is as yet unknown.[1] The disease develops most often early in life. The sexes seem equally liable to the affection.

Pathology.—In examining sections of the cord in these cases, a degeneration of the lateral columns, with a more intense and plainly marked sclerosis of the posterior columns, is found. This is similar to the lesion of locomotor ataxia.

Symptoms.—The symptoms resemble very closely those of locomotor ataxia, except that the lightning pains of the early stage and crises are not so marked as in the latter affection. Hereditary ataxia, moreover, involves the upper extremities more severely and earlier in the course of the affection.

The patient notices a feeling of weakness and uncertainty in walking, and soon it becomes apparent to others that the motions of the legs are not properly co-ordinated. The feet are placed wide apart in standing, and in walking the gait is practically that of locomotor ataxia. The movements of the hands become irregular and inco-ordinate, and a jerky irregularity develops in the movements of the head and neck, so much so that it may assume the aspect of an irregular tremor. Speech may also be impaired.

[1] Gowers: Vol. i., p. 380; Shattuck: Bost. Med. and Surg. Journal, vol. cxviii., 7, p. 168, Smith: Boston Med. and Surg. Journ., October 15th, 1885.

The knee-jerk disappears, but the plantar reflex remains. Sensation is affected in varying degrees in different cases, and trophic disturbances of the skin are not present. As a rule the sphincter muscles are not affected. Nystagmus is often present; the Argyll-Robertson pupil is absent.

Deformities are apt to come on in the later stages of the disease. In cases seen by the writers, marked rotary lateral curvature was present, and talipes equinus or equino-varus and permanent flexion of the knee are likely to occur.

Diagnosis.—In a clearly marked case, the walk is characteristic and exactly like that of ordinary locomotor ataxia. The deep reflexes are

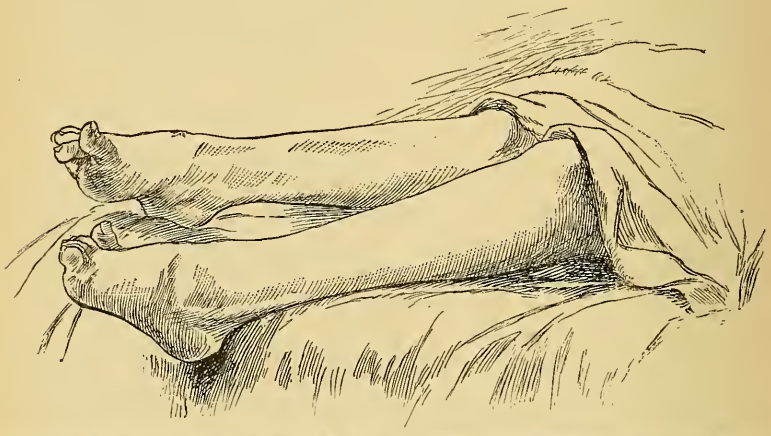

FIG. 486.—Deformity of the Feet in a Case of Friedreich's Disease. Hyperextension of the toes and club-foot. (Marie.)

diminished or absent and there is a certain amount of disturbance of sensation; the electrical reactions are normal. Isolated cases occur but rarely, and one finds most often a history of some such affection in other members of the same family, which of course aids very much in the diagnosis.

Prognosis.—The disease is essentially progressive, and the prognosis is bad in proportion to the rapidity of progress. Death usually occurs from intercurrent affections, but sometimes the disease lasts for thirty years or more and does not seem to have shortened life. It is not likely to cause death inside of ten or twelve years at the least, and nothing must be expected from treatment.

Treatment.—The treatment should be similar to that in common use in locomotor ataxia of the regular type. The general hygiene of the patient should be most carefully regulated, and skilful massage sometimes accomplishes much in keeping up the nutrition of the muscles and thus diminishing the patient's disability. Electricity in the same way is of

use, but it is distinctly second in importance to proper massage. Deformities should be corrected by tenotomy, etc., as they occur.

Among similar affections are *the cerebellar type of hereditary ataxia* described by Marie, differing chiefly in having exaggerated reflexes and ocular symptoms in addition to those described above.

Hereditary spastic paralysis must be mentioned as an affection of interest chiefly to neurologists, and not to the surgeon essentially different from the class described under cerebral paralysis.

Obstetrical Paralysis.

Obstetrical paralysis of the shoulder is an affection which is fairly common and often results in a disabled arm. It occurs most often after difficult labors when traction is made upon the head in head presentations, or upon the trunk when the head is delivered last. It may occur, however, after normal labors, as in a case recorded by one of the writers.[1]

It seems plain that the injury is due to a stretching and in some cases a rupture of the two upper roots of the brachial plexus. It has been found experimentally that the two upper roots give way first when traction is made, becoming very tense when the shoulder is pulled down, while the three lower roots remain lax under the same conditions.[2] The paralysis is of Erb's type and the nerves involved are the circumflex, suprascapular, musculo-cutaneous, and musculo-spiral.

The theory that it is a form of anterior poliomyelitis has not met with general acceptance.

It has been suggested that the paralysis is due to the pinching of the plexus between the clavicle and the transverse processes of the vertebræ.

The condition is made manifest immediately after birth by an inability to use one arm; it hangs powerless at the side, with the palm turned backward, and often the fingers are flexed tightly. If the arm is lifted from the side it falls lifelessly back into place, and although movement of the fingers is generally present, it is impossible to use the arm to any extent on account of the paralysis of the shoulder muscles.

The *prognosis* in the severer cases is not good as to recovery. The general experience of the writers has been that cases of complete paralysis of the arm following delivery which do not recover within a few weeks improve with great slowness, and rarely have a very useful arm. A patient, nineteen years old, was seen by one of the writers when the case had been under good treatment from the first. The affected arm was four inches shorter than the other, and although the grasp of the

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[1] Boston Med. and Surg. Journal, 1892.

[2] J. S. Stone: Boston Med. and Surg. Journ., 1899.

hand was good, the arm could not be lifted from the side. The patient was able to touch the chin with the affected hand, but could not raise it to the mouth or opposite shoulder. The use of the arm was, however, improving with each year. This will serve as an example of the average outlook in severe cases.

The *treatment* should consist in the use of a sling or supporting bandage at first to prevent stretching of the joint capsule and muscles. Later massage and electricity are likely to be of use.

In cases with contraction myotomy of the pectoralis major muscle followed by retention of the arm in a position to prevent contraction of the scar is of use.

CHAPTER XVI.

FUNCTIONAL AFFECTIONS OF THE JOINTS.

Definition.—Etiology and occurrence.—Frequency.—Symptoms.—Hip.—Knee.—Ankle.—Diagnosis.—Prognosis.—Treatment.

Definition.

Functional disorders of this class are usually termed hysterical or neuromimetic; but both terms are misleading. The first by common usage has become almost an expression of opprobrium, and the second by its derivation suggests mimicry. These cases may exist not only without deceit, but without any manifestation of imitation, intentional or unconscious.

The manifestations of this nervous disorder which will be considered here, are the affections of this class involving the spine, hip, knee, and ankle, although the other joints can hardly be considered exempt.

These disorders are probably dependent upon a disturbed nervous condition, perhaps due to a disordered blood supply, brought about by nervous exhaustion from over-growth, from disease, nerve strain, or from trauma. They are here termed functional, because there is no evidence, clinical or pathological, of organic disease.

It is ordinarily supposed that these disorders are seen in persons of an excitable, emotional temperament. Such is usually the case, but exceptionally the most aggravated type of functional affections may be seen in persons of calm and composed demeanor manifesting no exaggeration in statement or manner.

It is extremely difficult for a surgeon not learned as a neurologist to understand the nature of functional affections. The surgeon's training leads him to regard as of slight importance whatever has no pathological basis and no tangible objective reality; but it is to be borne in mind that in all these cases an undiscovered cause in all probability exists, as definite and undiscoverable as the nerve changes in tetanus or hydrophobia.

The condition of impairment of nervous resistance to pain is seen in the dentist's chair after several hours of suffering, on the operating-table when no anæsthetics are used, and sometimes in the recovery from anæsthesia or from intoxication. After prolonged extreme pain all individuals may become hysterical. The sound in a telephone is louder if the receiver is more sensitive, and in functional affections slight periph-

eral irritation usually unnoticed will produce uncommon mental impression if the recording nerve centres have become abnormally sensitive.

The concentration of the attention upon the affected part is another most powerful factor in producing and perpetuating the phenomena of functional joint disease. The familiar experiment of thinking fixedly of one finger serves to bring out a series of sensations in it which are not present in the other fingers, and illustrates as well as anything can do the power which concentrated attention possesses.

Etiology and Occurrence.

A study of the etiology of this class is disappointing. They belong to a large group of disorders of the nervous system, which present an interesting puzzle as to the nature of the causation. As a predisposing influence, an emotional temperament, which enters largely into the exaggerated statement of all subjective symptoms, must be considered in all cases. The influence of home training and discipline in the development of this temperament is important, as well as is heredity. Persons broken down in health by suffering or chronic disease become naturally in time incapable of bearing pain, and the statement of such patients is exaggerated and the endurance lessened.

Trauma is a frequent exciting cause. In certain cases the pain caused by a synovitis, for instance, seems to be perpetuated after its legitimate cause has disappeared. This is due to the patient's abnormal sensitiveness and self-concentration. Such sensations are to be classed as "habit pains." Again, slight sources of peripheral irritation, too slight to be an inconvenience to normal persons, may be a cause of severe symptoms in neurasthenics. Among such causes may be mentioned a short leg or a weakened foot of slight degree.

This condition of hypersensitiveness is sometimes to be seen in young girls about the time of puberty, and in elderly women at the time of the menopause, rarely in young children. Women in young and middle adult life are the most frequent sufferers. How far sexual irritation enters into these cases as a causative influence cannot be said with certainty, but in some cases it appears to be one of the disturbing factors which make up the disease. The statement cannot be too strongly made that, although these affections are seen mostly in young women at or after puberty, it must not be overlooked that they occasionally occur in young children, in boys, and also in men. Such cases are, however, not common.

Frequency.

The frequency of these affections is not generally recognized. Why a disturbance of the nervous centres should result in the manifestation of a group of symptoms so closely resembling those of serious joint disease

is but one of the many unexplained phases of this disorder. The same may be said of the direction of these symptoms to any particular joint; except that traumatism is in many cases the cause which determines the concentration of the attention upon some one joint. The direct exciting cause of the appearance of this disease is frequently not discovered.

Symptoms.

These affections may begin gradually, or they may be seen following trauma. Again they may be the outcome of a protracted convalescence from some joint injury. The symptoms presented may not be characteristic of this disorder, except that they are usually much exaggerated and out of proportion to the local signs. There is usually a condition of hyperæsthesia, especially of the skin, which manifests itself most clearly when any manipulation of the affected part is attempted. Although this is a very important factor in the determination of this class of affections, the absence of this hyperæsthesia must not be taken as sufficient evidence to exclude the disease. Another characteristic feature of these disorders is the fact that the objective signs vary from time to time. The stigmata of hysteria accompany many of these cases and when present are of great diagnostic importance.

Organic and functional disease are at times associated. A young woman with hip disease of a mild character will sometimes so exaggerate and emphasize her symptoms that the case may appear to be of the most acute sort, but careful examination will perhaps show that the disease is convalescent and that the real condition is very favorable. This can be detected only by a careful examination showing that the muscular stiffness varies much with the attention of the patient and that much pain is attributed to the slightest manipulation which can easily be performed without suffering or muscular spasm when the attention of the patient is diverted, while the muscular rigidity of chronic joint disease is a constant and not a variable resistance to passive manipulation.

Atrophy may be considerable, but it is generally not more than can be accounted for by disuse. It must be remembered, however, that this wasting may take place to a marked degree, but it differs very decidedly in amount from the extreme atrophy which is seen in real joint lesions.

Distortions of the affected limbs have nothing characteristic about them, except that they may or may not follow the malpositions of the limb which occur in real joint disease. The hysterical knee-joint is often flexed, the hip may be flexed and perhaps adducted or abducted.

In short the symptoms of functional joint disease have one distinctive characteristic, they are chiefly subjective, and objective signs of structural trouble are absent or not prominent. A familiarity with the objective signs of disease of the various joints is of course necessary in making

the diagnosis of functional troubles, and the foregoing chapters have dealt with those objective signs.

Certain symptoms often associated with functional disorders are ovarian tenderness and pain, baso-occipital headache, a feeling of suffocation as if a lump were lodged in the throat, and symptoms of this class.

The association of uterine disorders is common, and also another frequent accompaniment is found in the presence of errors of refraction in the eyes.

The surface temperature may be increased, local sweating may occur, and neurologists describe some swelling as an accompaniment of certain cases of functional disorder of the joints.

The correction of all sources of peripheral irritation is of course a matter of much importance.

Spine.

Functional affections of the spine have been considered in Chapter III.

Hip.

The symptoms which may present themselves under these conditions at the hip-joint may resemble hip disease in many particulars. There is often complaint of a severe pain in the limb, and any attempt to move the hip elicits expression of pain. There may be an absence of atrophy, and the pain is more likely to be localized at the hip than at the knee, which is the reverse of what happens in true hip disease. Unconscious movements at the hip-joint may be made more freely than in the painful stages of hip disease. In some instances, marked fixation at the hip-joint may constantly be present, but usually the stiffness in examination of the hip is great, but unconscious movements at the hip as in stooping are freer. The stiffness is more the stiffness of apprehension than the limited motion of early disease of the joint. The affection is rare in children, but the writers can mention cases in girls of eight and ten years.

The deformity may be marked and persistent, recurring quickly after reduction, but frequently the normal position is retained by very slight means, by a force far too little in amount to produce of itself any actual effect.

Creaking of the joint may be present in both hip and knee in functional affections. Uncommon at the hip, it is a frequent symptom of functional knee-joint disease. This symptom is described in many books as one to be sought for in destructive joint disease; it may be said again that it is not a common sign in joint disease. When destructive changes in the joint have progressed so far as to destroy the cartilage covering the ends of the bones, the joint disease will have assumed so acute a

type that muscular spasm to a marked degree will be present and prevent any motion between the eroded surfaces. This will naturally prevent the perception of any grating without the use of an anæsthetic, a proceeding which is wholly unnecessary and will allow a grating to be felt only in the more advanced cases in which the diagnosis must already be clear.

In all cases of functional affection of the hip any inequality in the length of the legs should be corrected as well as any abnormality of the foot.

Knee.

Functional disease of the knee-joints often simulates either chronic synovitis or ostitis. Pain and tenderness may be present, creaking is noted as an occasional symptom in functional affections, and at times there seems to be present an increase of surface temperature, which is apparently due to superficial hyperæmia. It may not be constantly present in the same case, and it varies in a way altogether unlike the behavior of the heat of chronic inflammation. More commonly the surface temperature of the affected side is reduced. The knee may be flexed, but during sleep that position may be involuntarily abandoned or the leg can be easily straightened, offering but little resistance. Contraction of the knee is often absent.

A moderate degree of muscular atrophy is present, and in some cases of prolonged disease of the joint peri-articular adhesions may be formed with contractions from adaptive shortening of the muscles.

In rare instances some swelling of the peri-articular tissues around the knee is observed in this class of cases. The swelling is transitory and does not involve the joint proper.

Nowhere does the diagnosis present greater difficulty than at the knee, where traumatism may loosen the semilunar cartilages to a slight degree or do some similar injury. The diagnosis of functional disease can be made only after the careful exclusion of all organic pathological conditions in both knee and foot. As our knowledge of abnormal conditions in the knee-joint becomes more exact fewer cases are classed as functional.

Ankle.

An hysterical condition of the ankle is not infrequent. It is most commonly met as a result of sprains which have been treated for too long a time by rest and fixation. A condition of muscular weakness, enfeebled circulation, and apprehension at slight pain ensues, and no attempt at the proper means of securing recovery is made, for the reason that the first attempt to use the disabled joint is painful and pain is regarded as a symptom indicative of inflammation.

In functional disease of the ankle an attitude similar to talipes varus or of flat-foot may be seen. In one case of talipes varus seen by the writers there was an exaggerated limp, and when the patient's attention was engaged the foot could be replaced and even over-corrected, yet at other times it presented a firm resistant contraction. The distorted attitude in both the knee and the ankle may be so constantly assumed as to cause a contraction of the hamstrings or tendo Achillis.

At the ankle most cases of functional affection are either the outcome of trauma or are associated with some abnormality of the foot.

The functional affections of the other joints present no points worthy of especial mention.

Diagnosis.

So much has been said about the characteristics of these affections in speaking of the various joints that there is scarcely need of mention here. It may, however, be said that the symptoms are often those of organic joint disease, but that the groups of objective physical signs are deficient and inconsistent with each other. The objective signs vary and are not so severe as the symptoms would lead one to expect. Pain is the prominent feature and muscular rigidity and similar symptoms are of varying severity, according to the concentration of the patient's attention. The presence of superficial hyperæsthesia and of signs characteristic of hysteria with an emotional temperament are facts which should excite attention.

In examining patients in whom a functional affection is suspected, much information can be gained by watching the movements of the patient in getting out of bed, moving in bed, etc. The limbs or back should be bared, and the unaided movements watched. Those suffering from organic disease of the hip or spine show a constant stiffness or attempt to guard or protect the affected limb, which is not displayed to so marked a degree in purely functional affections.

The diagnosis to be of value must in practically all cases be made by a process of exclusion. Again it must be remembered that functional and organic disease may exist in the same joint, that is, legitimate symptoms may be so exaggerated as to constitute a functional affection.

Prognosis.

If left to itself, a true functional affection of the spine or joints may improve gradually without special treatment, or it may remain unchanged until the joint becomes really injured by the continued inaction. In some cases a sudden and profound mental impression may prove stronger than the idea of local disease and a cure is effected. It is this that the surgeon strives to accomplish in certain cases, it is this that may be

brought about by faith cure or charlatanry, and rational treatment of a similar sort can likewise win excellent results if properly carried out.

The age of the patient and the duration of the affection are important in determining the outlook. The older the patient and the longer the course of the disease the less favorable is the prognosis.

The existence of some peripheral source of irritation, such as is so often found in an error of refraction in the cornea or in a misplaced uterus or a short leg or a weakened foot, renders it likely that the general condition will be helped by a removal of the irritating cause and renders the immediate prognosis perhaps more favorable.

Treatment.

In few disorders is a routine treatment of less use than in functional affections of the joints or spine. In severe cases the treatment begins with a contest of intelligence between the patient and physician, and treatment is futile unless the superiority of the physician is evident to both the physician himself and the patient. Especially important, from the outset to the end of the treatment, is an established diagnosis, on which the surgeon can rely. To attempt to follow out a treatment which shall be suitable to either functional or organic disease is fatal to a successful issue. Temporizing on the part of the physician at once makes successful treatment almost impossible. A definite plan of treatment must be formulated and adhered to.

The disorder usually manifests itself as a disability of a limb, the object of treatment being to overcome the disability. Various methods will be needed to effect this.

It is first necessary that the patient be brought into as nearly normal a general condition as possible. The improvement of the local condition is then to be considered and estimated, and finally the patient is to be trained to regain the use of the disabled limb. Another aspect of the case lies in the moral management of the patient, a matter which will be successful or not generally in proportion to the tact and judgment of the practitioner. Some patients can be commanded to walk and will do so and a cure is accomplished, while in the majority of cases to attempt a measure of this sort would lead to a permanent loss of influence on account of the failure of the surgeon to have his directions carried out. Elaboration of treatment is desirable in many cases and a rigid adherence to a careful and continuous routine of exercises, feeding, and medication must be insisted upon. In no class of diseases do proper placebos work more good. A full description of the measures necessary for the proper treatment of neurasthenic patients does not fall within the scope of this work, but this class of cases cannot be successfully treated unless due attention is given to regulating and improving diet and general condition, and correcting sleeplessness.

For the treatment of the local condition, the physician has to decide between the necessity of correcting any existing distortion or local improper conditions of circulation or muscular weakness of the limb or back, and the danger of increasing the expectant attention of the patient by too great attention to the local condition. It is for this reason that counter-irritation and the cautery are to be avoided. It is essential that the local condition should not be made light of by the surgeon, and the reality of the symptoms must be accepted and the disability recognized. A probable hypothesis explaining the condition must be assumed, and treatment based upon this should be carefully and consistently carried out. Any statement that the affection is a trivial nervous disorder or that it can be overcome by exercise of the will is in most cases an error.

An important part of local treatment is the improvement of the circulation in the part affected, and strengthening of the surrounding muscles. This can be done by massage, local hot-air baths, electricity, and gymnastics, and the functions of the part gradually resumed by slight passive motion.

In general the beneficial effect of the local measures adopted must be insisted on, and by a graduated amount of enforced exercise progressively increased, the patient may be surprised into finding herself daily doing more without feeling more pain. Sometimes it may be only practicable to make the patient take two steps a day, but the advance to three and four steps is an important gain. It may be repeated that without a certainty on the physician's part that he is dealing with a functional affection and without a rigid adherence to his formulated plan of treatment, success is not often to be obtained.

Great benefit can be obtained by graduated exercises in this class of cases. Another useful way of accomplishing this result is by means of mechanical passive and active exercises according to the method introduced by Zander.

Appliances as a rule should be avoided—but in some cases they are temporarily needed, to enable the patient to go about more freely in cases with marked muscular weakness. They should be discarded as soon as is practicable; in the severer forms crutches will be an aid when walking is first attempted, and plaster jackets have been occasionally used with advantage. They should, however, be employed only for a short time, as they increase the muscular weakness. The same is true, but to a less degree, of the lighter forms of appliances—spring corsets and similar light appliances.

In functional affections of the hip, knee, and ankle it is sometimes necessary to employ crutches in order to give locomotion and exercise. Crutches should be used sparingly, and only temporarily, inasmuch as there is danger of the patient becoming habituated to them.

When contractions and malposition of the limbs are present, these

should be corrected either by operation or by mechanical means. Operative measures are usually simple, as under an anæsthetic the limb can be pulled readily into normal position, while only in severe cases is tenotomy of the resisting muscles needed. Appliances will be required to retain the limb in the corrected position. Tin or light wire splints strapped upon the limb are preferable to fixed bandages, as they confine the limb less.

Contraction of the hip as well as of the knee can ordinarily be prevented from occurring by posterior splints, as the psoas contraction in a functional affection of the hip usually in time yields to the weight of the extended limb if the patient is upright and the knee prevented from bending by a ham splint.

Light cases of functional affection of the hip will be best treated at first by the use of crutches and the elevated shoe to the well foot, aided by gymnastic exercises for the limb of such a character as the patient can endure. The elevated shoe should be lowered and removed gradually, and in the same way crutches should be shortened and replaced by a cane, and finally all support discarded by gradual stages. The use of a hip splint will often not be found advantageous on account of its weight. Traction by weight and pulley is rarely needed, but is sometimes advisable. Treatment of light cases of disease of the knee and ankle may often require the temporary use of crutches and possibly fixation appliances for a while.

Much judgment is required to determine what cases of functional affection of the hip, knee, and ankle joints are to be treated by rest, by protection of the limb, or by use.

Rest in bed is to be avoided unless the patient is in a marked neurasthenic condition needing quiet. In some instances confinement to bed is unavoidable during the correction of deformity.

In functional affections of the limbs the strength of the muscles controlling the diseased joint should be increased by graduated exercise, until the patient is surprised into an unconscious use of a previously disabled limb. If removal of crutches or supports is attempted before the strength of the limb is certain, a mistake is made and crutches will be resumed by the patient. If the strength of the part has been regained, use is possible if the attention of the patient expectant of suffering can be diverted until the painless use of the part has been demonstrated.

Whatever the methods of treatment to be instituted, it is absolutely essential that the physician should have complete control of the management of the case without interference of friends or relations. Sometimes it is therefore necessary to take the patient away from home for the time being. In many cases the home influence is a most important factor in inducing and keeping up this condition, so that a removal from these influences is essential.

In cases in which functional symptoms are superadded to an organic lesion, much skill and judgment are required in treatment.

In all these varieties of functional affections, the principle of treatment is the same—temporarily to protect the affected part from strain and painful use, to improve the circulation and increase the muscular strength, and as the condition improves to train the patient to the gradual resumption of the normal use of the limb.

CHAPTER XVII.

RICKETS.

Definition.—Pathological anatomy.—Occurrence and etiology.—Symptoms.—Diagnosis.—Differential diagnosis.—Prognosis.—Treatment.

Definition.

Rickets is a constitutional disease which affects young children. Its chief characteristics are manifested in the osseous system, where there is a local or general disturbance of the normal process of ossification, as a result of which the epiphyses become enlarged and the affected bones become soft and pliable; growth is delayed and deformities of a serious character arise. The affection itself does not belong to the category of surgical diseases; but the resulting deformities, which demand strictly surgical treatment, are connected with the disease itself so intimately that a brief consideration of the subject is necessary. The affection itself is so fully discussed in books relating to the diseases of children that the reader can be referred to them for any detailed account of the disease.

The disease is known in English as rickets or rhachitis. Other names for the affection are: morbus anglicus, articuli duplicati, englische Krankheit, Zwiewuchs, doppelte Glieder, nouure, rachitisme, etc.

Pathology.

Rickets occurs especially at the time when the bone growth is at its maximum and its most obvious feature is a defective calcification of the bones, in consequence of which secondary changes occur. The normal process of growth demands:

1. Multiplication of cells. 2. Calcification. 3. The formation of medullary spaces and ossification.

On the epiphyseal line where growth mainly occurs, the process of growth consists of the apposition of cartilage which is absorbed and replaced by bone. In rickets the pathological changes are most marked at the junction of the epiphyses and the shaft. The epiphyseal cartilage, which should normally be a thin layer, in rickets appears as a broad, reddish-gray, translucent cushion, while the whole epiphysis is enlarged.

There is thickening especially of the transparent zone of the multiplied cartilage cells, the line of calcification is thin or may be wanting in places, the formation of medullary spaces extends into the zone of calcification and possibly through it. In the region of the centres of ossification at the ends of the diaphysis there is an increase of cartilage cells and a lengthening of cell columns, calcification occurs in scattered patches and not at a definite centre, vascularity is great, the formation of medullary spaces is increased but the deposit of bone inside these spaces is wanting or irregular, its place being taken by "osteoid tissue."

The periosteum of the shaft is hyperæmic and thickened and boggy and often adherent to the bone. The subperiosteal layer, which normally is thin and scarcely noticeable, in rickets is thick and appears dark and like spleen pulp. It is a soft friable tissue called "osteoid tissue," which consists of a bone tissue deficient in lime, with bone cells often large, and a fibrillated ground substance.

The medullary bone is more hyperæmic than normal medulla at this age. The intercellular substance may show mucoid degeneration or be fluid. It does not seem that lime is dissolved out of the finished bone, but that resorption of such bone *in toto* is the important element. Pommer, Mueller, and Virchow believe that resorption in rickets is not increased; Kassowitz and Ziegler believe that it is. Clinically certain cases of rapid softening seem to show increased resorption. In addition to this is the fact that the fresh bone formed tends to contain a diminished quantity of lime. After the active process has ceased lime is deposited in the "osteoid tissue," and the result is a thick and heavy bone.

The chemical analysis of rhachitic bone shows a percentage of 19 to 53 per cent of ash. Zalesky found in normal bone 65 per cent of ash, Von Bibra found in a two-months-old child 65 per cent of ash, and in a five-year-old child 68 per cent of ash.

The upright position apparently is not necessary for the development of deformity, which may be caused by muscular contraction in the case of the long bones.

Bodily weight and muscular action are also likely to curve and twist the softened bones, and there is hardly any limit to the deformity that might result if a reparative change did not set in.

Ossification after the process is over becomes excessive and may be spoken of as petrifaction or eburnation, rather than true ossification. Infractions or partial fractures, with the break on the concave side of the long bones, may occur. The ligaments become relaxed and stretched, and the muscles flabby from disuse. The spleen is ordinarily enlarged and sometimes the liver. Catarrh of the alimentary canal and bronchi are common accompaniments.

In rickets of the skull the meninges and brain may be secondarily affected.

The other pathological changes are more properly to be considered under the head of symptoms.

Occurrence and Etiology.

Rickets is an affection occurring commonly during the first dentition. Cases of rickets are, however, described as congenital and others as occurring during adolescence.

Congenital rickets, or fœtal rickets, is regarded as doubtful by such authorities as Ziegler and Vierordt.[1] In the cases described the periosteal lesions are absent and the epiphyseal changes do not agree accurately (Ziegler). According to Vierordt, most of these cases were not rickets at all, but the cases of Fischer, Winkler, Bornträger, Smith, and Kumpe showed histological changes not dissimilar to rickets. The cases of Kassowitz are not considered convincing by Vierordt. Other cases have been reported by Jacobi,[2] Gueniot,[3] Henoch,[4] Shattock,[5] Lewis Smith[6] (with skeleton), Bednar,[7] and others. Kaufmann reports twelve cases of so-called fœtal rickets which he would call "chondrodystrophia fœtalis." Whatever the technical pathological point of view may be, a condition closely resembling rickets from a clinical point of view occasionally arises during fœtal life.

Rickets in Childhood.—The common time of occurrence is early in childhood; cases are reported in which the "rhachitic rosary" was seen as early as the fourth[8] and sixth[9] weeks after birth. The following collection of 1,876 cases will show the tendency of the disease to occur in the first two years of life.

	1st yr.	2d yr.	3d yr.	4th yr.	5th yr.	Over 5.
Guerin	98	176	35	19	10	5
Bruenische	20	79	47	7	6	4
Rittershain	266	154	62	15	7	17
Ritsche	72	109	25	9	4	..
Baginsky	256	313	63	..	..	..
	710	831	232	50	27	26+

Rickets seldom begins before six months or after three years.

The rickets of adolescence or late rickets is a disease which affects

[1] Vierordt: "Rachitis und Osteomalacie."
[2] Jacobi: Am. Journ. Obst., November, 1870.
[3] Gueniot: Rev. Mens. des Mal. de l'Enfance, January, 1884.
[4] Henoch: "Diseases of Children."
[5] Shattock: Lond. Path. Soc. Trans., 1881.
[6] Smith: "Diseases of Children."
[7] Quoted by Lewis Smith.
[8] Parry: Am. Journ. Med. Sci., January, 1872.
[9] Gee: St. Barth. Hosp. Rep., vol. iv.

persons at about the age of puberty;[1] it is generally[2] associated with albuminuria, and its etiological relations are decidedly obscure. The physical signs are practically the same as in the rickets of early life, except that the epiphyseal enlargement is generally not so great. Drewett reported a case to the London Pathological Society in 1880 in which a dissection of the skeleton showed the same characters as in early rickets.[3]

A committee of the Pathological Society examining this case reported the changes to be characteristic of rickets. Clutton has reported two cases[4] of the sort.

FIG. 487.—Chondrodystrophia Fœtalis, "Congenital Rickets."

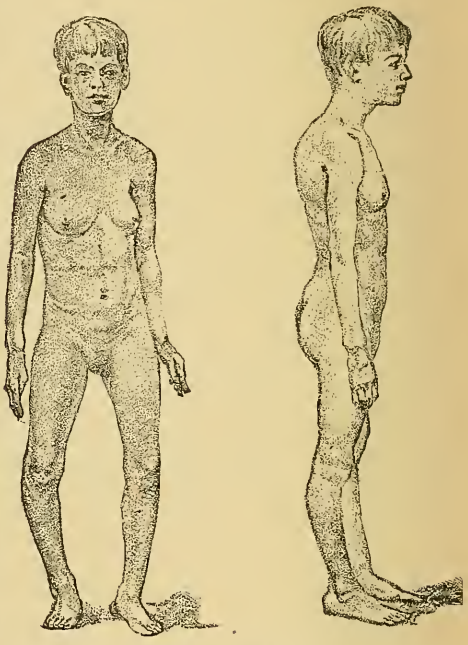

FIG. 488.—Rickets of Adolescence. (Clutton.)

In 2,595 cases of rickets reported from various authors, there were 1,337 boys to 1,258 girls.

Heredity.—The weight of authority[5] seems to favor the view

[1] Lucas: Lancet, June 9th, 1883.

[2] Keetly: Annals of Surgery; Palm: Practitioner, xlv., 1890, p. 275; Duplay: Gaz. des Hôp., 1891, p. 1397; Robert Jones: Brit. Med. Journ., 1896, i., 341.

[3] Maxon: Guy's Hospital Reports, 1878.

[4] St. Thomas' Hospital Reports, vol. xiv.

[5] Parker, Vogel, and von Rittershain: "Die Path. und Ther. der Rachitis," Berlin, 1863.

that a weakness of constitution is inherited rather than the disease as such.[1]

As might be expected, the later children of a large family are much more liable to rickets than their older brothers and sisters.

Inasmuch as rickets is a disease of malnutrition, the commonest causes are to be sought in the immediate surroundings of the patient. Broca's definition of it best expresses the situation when he speaks of it as representing, "the ultimate effects of everything which interferes with the nutritive processes during the rapid growth of infancy."

Locality.—In southern and central Europe the disease is especially prevalent, particularly in the cities. In America it is less frequent, and in the European cities it varies very much. It is rare in sub-tropical climates, almost absent in the tropics, and is said not to occur in the arctic regions. Even in the zones where it occurs it is rare in high altitudes. It is most seen in cold moist climates.

In America the disease is neither very prevalent nor very severe, and, except in colored children or in Italians and Portuguese, very great deformity is rare. The great bulk of cases seen in the northern cities of America present essentially a mild type of rickets compared to what is seen in Europe.

A number of children were taken at random in one of the poorest quarters of Boston and carefully examined for rickets, and the results have a bearing on the question of etiology. The district was one inhabited by Italians, Irish, and Portuguese, and represented the lowest class of the population. One hundred children between the ages of one and six were stripped and examined; 60 showed no signs of rickets, while 40 were more or less rhachitic. The following figures represent the very decided effect of nationality:

Parentage.	Total.	Rhachitic.	Not Rhachitic.
Portuguese	24	20	4
Irish	51	7	44
Italian	5	3	2
American	2	0	2
English	8	5	3

The prevalence of rickets among the colored population in northern cities is most striking, and the disease is not by any means so common in the negro population of the southern cities. The great susceptibility to rickets which is shown by the inhabitants of southern Europe has never been accounted for.

Bad hygienic influences, such as poor ventilation, damp dwellings, crowded rooms, etc., have a very marked sway in producing rickets, and this factor is one which continental writers make very prominent.

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[1] Jenner: Med. Times and Gazette, 1860, i., 460.

In America, where the conditions of life among the poor are very different, rickets is almost exclusively produced by improper feeding. Cheadle,[1] representing an extreme point of view, stated that he had seen only one case of rickets which arose in a child suckled by a healthy mother, and in this case the mother became pregnant during lactation.

Several theories as to the causation of rickets have been advanced: (1) that the proportion of lime in the ingesta was deficient or that the absorption of it was deficient. Analyses of various milks and food taken by rhachitics seems to exclude the possibility of a deficiency of lime in the ingesta (König, Forster, Gorup, Besanez). In cow's milk there is more lime than in human milk. Analyses of human milk from mothers of rhachitic children showed no deficit of lime (Seeman, Pfeiffer). Rüdel found the lime in the urine of rhachitic children not definitely different from that of normal children, and on giving them an excess of lime in their food found it absorbed and excreted as well as it was in healthy children.

(2) A theory has been advanced that lactic acid is generated in excess in the intestinal canal by the fermentation of starchy food imperfectly digested; this, uniting with the lime of the bones, removes the lime as a soluble salt and acts also as an irritant to the osteoplastic tissue.

This and similar theories that the softening of bone is due to other acids (carbonic dioxide, uric acid, etc.) are as yet unsubstantiated.

Wegner found that small doses of phosphorus increased bone formation, while dosage of phosphorus with food poor in lime did not prevent rickets. Kassowitz claimed similar changes from the administration of phosphorus without modifying the diet, but his results have been questioned (Vierordt).

The infectious theory of rickets is not supported by proof.

Another theory lays the fault upon insufficiency of fat and proteids in the diet of rhachitic children. Artificial farinaceous foods contain a very much smaller percentage of fat than milk does, and the experience at the London Zoölogical Gardens lends much weight to the idea that the deprivation of fat and proteids from the diet of young animals is a most important factor in the production of rickets. In menageries, where animals live under highly artificial conditions, rickets attacks young lions especially, and is the cause of death in a large number of cases. Ostriches, pheasants, and poultry under the same conditions have a softened condition of the bones.

Bad hygienic surroundings and improper food or wholly insufficient diet are not the only factors, because thousands of children grow up every year under these conditions without becoming in the least rhachitic.

The subject of the relation of syphilis to rickets must be passed over very briefly as having only an incidental interest in this treatise. The

[1] Brit. Med. Journal, November 24th, 1888, p. 1145.

present view rather regards syphilis as an indirect cause of rickets in impairing the general constitution.[1] The common experience is to find a small proportion of syphilitics among rhachitic children.

Malaria has been claimed by Oppenheimer[2] as the main cause of rickets, but there is no reason to take the theory seriously. Chronic tuberculosis in the parents, as well as debility from any cause impairing the nutrition, may be the cause of rickets. Any exhausting disease in the child may be followed by rickets, while bronchitis is too common a symptom of rickets to be considered its cause, as some writers would do. Finally, in certain rare cases no cause can be assigned for the occurrence of the affection.

Symptoms.

The disease is so often the outcome of a long period of ill health that it is difficult to say when the rhachitic symptoms begin. Among the commonest early symptoms are restlessness at night, profuse sweating, especially of the head, and constipation perhaps alternating with diarrhœa, but the diagnosis cannot be made from the premonitory symptoms.

The belly becomes large and distended with flatus, and although the appetite may be unimpaired, the child looks white and pasty and loses flesh. At this stage one may encounter the characteristic symptom of general tenderness of the body, but many cases never present this symptom. This tenderness is sometimes confined to the bones and is manifested only on deep pressure, while at other times the muscles are exquisitely tender, and the gentlest effort to lift the child may cause him to shriek with pain. This symptom disappears readily under treatment.

The so-called "paralysis of rickets" is at times an accompaniment of this stage, and is generally brought to the parent's notice by the child's inability to walk or sometimes to stand. At other times it may be more severe and take the form of inability to use the arms as well as the legs. There is no permanent lesion of the nervous system in these cases, and a careful examination in the recumbent position shows that the child's

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[1] Ranke: Int. Med. Cong., 1881, vol. iv.; Cazin and Iscovesco: Arch. gén. de Méd., September, 1887; Lannelongue: Soc. de Chir., 1881, p. 370, 1883, p. 4; Poncet: Bull. de la Soc. Anatomique, 1874; Kassowitz: "Die Syph. als die Ursache der Rachitis," Int. Cong., London, 1881, vol. iv.; Taylor: "Syphilitic Lesions of the Osseous System in Infants and Young Children," London, 1875; Parrot: Bull. de la Soc. de Chir., Paris, 1883, 174; Despres: Bull. de la Soc. de Chir., April 5th, 1883; Magitot: Trans Int. Med. Cong., vol. iv., 1881; Capitan: Bull. de la Soc. de Chir., ix., 322; Capistrel: "Cont. à l'Étude de l'Étiol. du Rachitisme," Thèse de Lille, June 21st, 1883; Gibert: Soc. de Chir., 1883; Girard: Revue de la Suisse Romande, July 5th, 1883; Pini: Semaine méd., 1885, p. 325; Gaillard: France méd., January 7th, 1886, p. 14; Discussion Int. Med. Cong., 1881, p. 52, vol. iv.

[2] Deutsches Archiv f. klin. Med., 1881, xxx.

muscular movements are but little impaired. The disability is to be attributed to the muscular weakness and the bone tenderness, particularly to a periosteal tenderness at the muscular insertions.[1] The electrical reaction is normal, the reflexes are not affected, and recovery is certain if the child lives. This pseudo-paralysis is an early symptom of rickets, and as a rule precedes any marked osseous change, which adds to the difficulty of its recognition. The most difficult affection from which to distinguish it is the disability due to simple weakness in non-rhachitic children, but the distinction is not one of any practical importance.

Fever is most often absent or due to some complication, such as bronchitis. Convulsions may occur at any stage of the disease, especially when there is any tendency to craniotabes.

In certain cases these symptoms are all so acute that some writers would make them a separate class under the head of acute rickets. Some cases so reported belong to infantile scurvy, in others the anatomical lesions and the symptoms are the same as in ordinary rickets except for their greater severity, and they seem to belong clearly enough to the same group as the slower cases.[2]

Changes in the Bones.—Some time after these general premonitory symptoms the changes in the osseous system begin to be evident. Enlargement of the epiphyses appears, especially at the wrists and anterior ends of the ribs. Enlargement of the lower end of the radius and ulna is practically universal, whereas enlargement of the lower end of the tibia and fibula occurred in only 400 out of 1,000 cases.[3] These enlargements do not involve the joints. At the ribs one finds the "rosary," a series of bead-like enlargements easily felt at the junction of the cartilages and the ribs, and a small degree of epiphyseal enlargement is easily detected here, and not likely to be mistaken for anything else. When these changes have occurred, the bones have already softened and curvatures of the long bones may have begun. In the deep-seated epiphyses, like the hip and shoulder, one does not notice the change.

The proliferating layer between the epiphysis and the bone may become so thick and so soft that separation of the epiphysis and much consequent deformity may occur; but such an event is rare.

The forces that work to produce deformity in the softened bones are muscular action, gravity, atmospheric resistance, and the pressure exerted on bony structures by growing organs.

It will be best to consider seriatim the changes which rickets produces in the different parts of the body.

In the head, certain changes are so constant that one depends much on them for the diagnosis. The typical head of rickets has a high,

[1] H. W. Berg: N. Y. Med. Rec., November 16th, 1881.

[2] Gee: St. Barth. Hosp. Rep., xvii.; Barlow: Med. Chir. Trans., vol. lxvi., 159.

[3] Reeves: "Pract. Orthopedics," p. 14.

square, prow-shaped forehead, with a decided prominence of the lateral parts of the frontal bones (frontal eminences) and sometimes the parietal eminences as well. In general the head appears to be larger in circumference than normal. This is due, when it actually exists, to thickening of the cranial bones.[1]

The expression of the face is intelligent, although the face may show the ill-health of the child, and the superficial veins of the scalp and face may be enlarged.

The anterior fontanelle, which should normally close at about the eighteenth month, remains widely open and does not ossify until perhaps

FIG. 489.—Rhachitic Spine. Enlarged epiphyses at wrist.

FIG. 490.—Enlarged Epiphyses at Wrist.

the third year or even later. This, however, is not enough to establish the fact that the child is rhachitic until the age of two years has been reached. The posterior fontanelle sometimes remains open for months. The sutures may also remain open longer than they should, and in such cases, after ossification, they are apt to show a depressed gutter of bone where they have been; and such a depression is not uncommon at the site of the closure of a fontanelle. Sometimes, however, prominence takes the place of depression.[2]

The name craniotabes is applied to an abnormal thinness of portions of the parietal and occipital bones which yield to gentle pressure and give the sensation of crackling parchment. The affection is uncommon

[1] Rep. of Lond. Path. Soc., Lancet, ii., 1880, 1017; Patholog. Soc. Trans., 1881, Discussion on Rickets; "Klinik der Pädiatrik," ii. Bd., 1877.

[2] Schwenke: "Ueber den Einfluss der R. auf den Durchbruch des Milchgebisses," Inaug. Diss., Halle, 1886.

in the mild degree of rickets seen in America. The affection, however, occurs in simple rickets.

Hyperæmia of the brain and meninges may be an accompaniment. With this hyperæmia comes the likelihood of hydrocephalus, either external or internal, and the accompanying cerebral changes, so that hydrocephalus becomes a complication of rickets which is not very rare.

Deformities of the chest are among the most common produced by rickets and they occasionally exist without any well-marked signs of rickets elsewhere. It is not unusual to see young girls about the age of puberty who have discovered some inequality in the chest or prominence of the lower ribs perhaps, but who present no other signs of rickets.

FIG. 491.—Characteristic Rhachitic Head.

FIG. 492.—Rickets with Hydrocephalus.

In these cases it seems reasonable to assume that a slight degree of bone softening existed in childhood and passed away without leaving any other sign than the chest malformation.

Deformities of the chest are produced by muscular action of the muscles connected with the thorax and also by the atmospheric pressure on the thoracic walls. In a typical rhachitic chest the clavicles are shorter and more curved than they naturally should be. The chest is narrow and prominent in front; it shows the effect of lateral compression, and the sternum projects so prominently that the name of pigeon breast, or pectus carinatum, is commonly given to it. The weakest part of the chest cavity is at the junction of the ribs and cartilages, and it is here that the chief yielding takes place and the ribs allow themselves to be pressed in laterally, while the sternum is pushed forward. At other times the ribs are pushed together laterally while the sternum is pressed back. This leaves a depression where the sternum should be and is spoken of as "funnel chest." Again, one side may yield more than the other and

a prominence of the front part of the ribs on one side of the sternum may be the only deformity. A transverse depression in the chest known as Harrison's sulcus also occurs in the typical cases. It is most evident just below the nipples and has been thought to be due to the action of the diaphragm at its attachment. It is, however, above that level. The softening of the ribs is said to occur (Vierordt) after the changes in the skull and before the changes in the extremities. The prominence of the abdomen, which is almost universal in well-marked rickets, adds to the deformity of the chest by the elevation of the lower ribs, on

FIG. 493.—Deformity of Spine in Rickets.

account of the underlying distention. When the abdominal distention disappears, this flaring of the lower part of the ribs is sometimes left behind.

Kyphosis.—A very common deformity of the spinal column due to rickets is a bowing backward; a gradual bowlike curve (involving the dorsal and lumbar regions). It is a uniform flexion of the whole column and is most prominent at the junction of the dorsal and lumbar regions. This attitude seems the result of a long-continued sedentary position with a weakness and tenderness of the muscles which fail to hold the spine in the erect position. Rhachitic children, as a rule, learn to walk late, and this peculiar flexion seems a persistence and exaggeration of the position which the spine naturally assumes in young babies, who are propped up in the sitting position. The prominence of the vertebral spines at this place is often quite sharp and simulates Pott's disease most closely.

A rhachitic spine should be flexible to passive manipulation, however much it may be curved, but occasionally much muscular irritability accompanies this condition, and at times cases are seen of rhachitic curvature of the spine in which the curved part of the spine is inflexible to manipulation. In those cases, when the child is laid on its face (as described under Pott's disease) and lifted by its legs to test the flexibility of the column, the spine is rigid.

Scoliosis is a common deformity due to rickets, which has already been considered.

Lordosis is the third of the common deformities due to rickets, and gives rise to a characteristic attitude, the importance of which is much overlooked.

The Rhachitic Attitude.—The attitude of a child affected with well-marked rickets is characteristic. It exists in most marked cases of knock-knee and bow legs and sometimes in a less degree with milder grades of the affection. The child stands with the legs apart, the thighs flexed and the knees bent, the back is arched and the shoulders are thrown back. The cause of this attitude has never been quite clearly established.

It is undoubtedly in a measure the persistence of the infantile attitude, the position which children assume who are just learning to walk. Children with rickets have weak muscles as well as weak bones, and the condition of such a child approaches that of an infant, in large measure; hence he stands and walks with the least expenditure of muscular force. This explains certain cases. Another factor is the protuberant abdomen the weight of which the child seems to counterbalance by leaning backward.

Deformity of the pelvis is induced by rickets because the body weight is borne by a bony arch which has lost part of its supporting power, and bends under weight. These pelvic deformities have only a significance in regard to obstetric surgery, they occasion no trouble or noticeable deformity in themselves; but in females, when pregnancy comes on, their existence is a matter of the gravest importance. The subject is fully treated in all books upon obstetrics.

Except in very severe cases, the arm bones are not seriously curved. The curvatures follow no especial rule, but generally they are an exaggeration of the normal curves of the bones. The curvature of the arm bones may be due to creeping or to lifting the child continually by taking hold of the forearm in one place, but as a rule is the result of muscular action.

Coxa vara may exist in the hips. The condition has been already described.

The rhachitic deformities of the legs are of such importance that they will be considered under the separate headings of knock-knee and bow legs.

Flat-foot is a very common accompaniment of rickets. The affection is considered under flat-foot.

In general, the skeleton is not only deformed but stunted, and persons who have rickets severely in childhood do not reach average size in adult

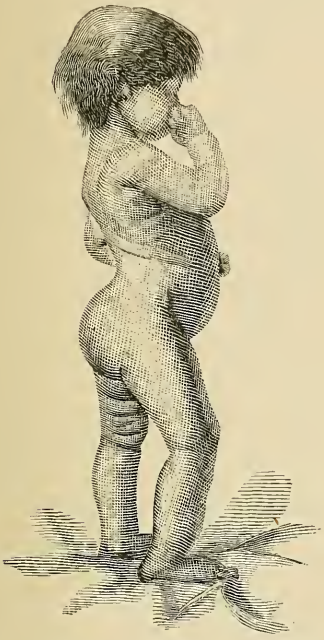

FIG. 494.—Attitude of Severe Rickets, Showing Lordosis and Rotation of Pelvis.

FIG. 495.—Extreme Deformity from Rickets.

life as a rule. The osseous deformities, as a rule, persist to a certain extent through life. Notably is this true of the shape of the skull and the chest.

Laryngismus stridulus is an occasional complication of rickets.[1]

Important symptoms relate to the eruption of the teeth; not only are they late and irregular, but they are imperfect generally, and unable to resist decay. On the average the first tooth appears about the ninth month, and not only is the interval between the teeth longer, but the order of appearance is often abnormal. The first dentition does not end on the average until the third year. The teeth may present the characteristics of the so-called "Hutchinson's teeth."

Latent rickets is a term of very doubtful utility; it is used chiefly in

[1] Money: Lancet, January, 1889; Goodhardt: "Dis. of Children," p. 645.

speaking of cases in which only one symptom or one group of symptoms becomes evident, and it does not seem to mark out any one type of the disease, although, of course, it must necessarily be applied only to mild cases; but it may be assumed that the existence of localized rickety bone changes is perfectly possible, and such a theory is needed to explain cer-

FIG. 496.—Extreme Curvature of Bones.

tain cases of bow legs in children, *e.g.*, when no symptoms of general rickets are present; and there is this local softening of the leg bones which is not likely to be due to any other than a rhachitic cause.

DIAGNOSIS.

The diagnosis in fully developed rickets is simple; but when the affection is beginning, its recognition may be attended with difficulty.

In beginning rickets, certain symptoms are suggestive; these are: restlessness and sweating at night, and especially universal tenderness when acute articular rheumatism is not manifestly present. In well-marked cases the diagnostic points are the epiphyseal enlargement of the ends of the long bones, especially the wrists and the sternal ends of the ribs; the prow-shaped head; the deep, small chest and the big belly. Delayed dentition and an anterior fontanelle open long beyond the proper time are equally characteristic. If the disease has advanced still further, one often finds curvature of the bones of the legs and arms.

Delayed dentition is so important a sign in the diagnosis of rickets that it deserves especial attention. If no teeth have appeared by the ninth month the child is very likely rhachitic, and if no teeth appear at the end of the twelfth month the child is almost certainly rhachitic; but the latter are extreme cases and exceptional ones. In general the delayed appearance of the teeth should direct attention to the possible ex-

istence of rickets. The second symptom, which is of equal value, is the delayed closure of the anterior fontanelle. If this remains open until the age of two years, there is little doubt that the child has rickets. It should normally close about the eighteenth or twentieth month.

Delay in learning to walk should also excite suspicion of the presence of rickets. The cough and general tenderness so often associated with rickets are apt to obscure the affection, inasmuch as they tend to mislead parents and physician.

Differential Diagnosis.

There are certain symptoms found at times in both syphilis and rickets. These are "Hutchinson's teeth," craniotabes, and flexible bones, which are occasionally seen in syphilis. Most cases of congenital syphilis present no resemblance to rickets and are not to be confused with it. The differential diagnosis can be made on the general characters of the two affections.

Acute articular rheumatism can be distinguished from rickets by the presence of high temperature, joint swelling and tenderness, particularly acute at the joints, while the tenderness of rickets is more often general or limited to the epiphyses. Among young children rickets is much the more common of the two diseases.

The condition induced by malnutrition is sometimes hard to distinguish from rickets. Feeble children with large heads and flabby muscles learn to walk late, and this very fact often suggests the presence of rickets and the existence of rhachitic paralysis. In general the diagnosis can be made by the absence of the characteristic signs of rickets; but it is not to be made off-hand, but with very great care, and at times it may be necessary to wait for time and treatment to determine whether the child is suffering from the early stage of rickets or not.

From Pott's disease rhachitic spinal curves are sometimes not easily distinguished. Young children a few months old are not infrequently brought for examination on account of a prominence in the back and a great deal of crying in being lifted or handled. At the junction of the lumbar and dorsal regions a prominence may be present involving several vertebræ, which may or may not be obliterated when the child lies on its face, and is lifted by its feet from the table. Sometimes the constitutional evidences of rickets are so marked that the diagnosis is clear; Pott's disease, when it occurs in young children, begins often in this location and in this way. The writers have seen cases in which doubtful kyphoses of the same characteristics have been kept under observation and treatment, and one case has proved to be rhachitic, while another developed into clearly marked Pott's disease. Rhachitic kyphosis is more common than Pott's disease in children under eighteen months, and

although the presence of rickets does not rigidly exclude the possibility of Pott's disease, yet when the general signs of rickets are present, it is safe to assume that in most cases the kyphosis will disappear under treatment. In doubtful cases time alone will clear up the question.

Pigeon breast due to Pott's disease is often found when there is a large deformity in the dorsal region of the spine, and the bodies of the

FIG. 497.—Rhachitic Curvature, Simulating Pott's Disease.

vertebræ have given way. Beading of the ribs is absent and it occurs only after the knuckle in the spine is very evident.

From osteomalacia occurring in children rickets can hardly be differentiated during life.

PROGNOSIS.

When the disease is left to itself it generally runs its course, and after a decided degree of bony deformity has occurred the process of bone softening is spontaneously arrested, and the bones harden in their deformed condition.

Spontaneous arrest of the disease may take place at any stage without treatment, but, as a rule, in severe cases not before a serious degree of bony deformity has been produced. A fatal issue may be brought about by the complications of the disease. In untreated cases the prognosis is unfavorable in those which have begun at an early age; when the disease is treated efficiently the prognosis, as to life, is always favorable unless some serious complication is present, and the disease is, as a rule, easily amenable to treatment.

The arrest of the disease at an early stage is most important, as it is highly desirable that, if possible, deformity should be avoided.

The kyphosis above alluded to disappears under proper treatment. Lateral curvature is permanent when not treated. The complications, craniotabes, laryngismus stridulus, bronchitis, diarrhœa, and paralysis, improve as the general condition becomes better, and finally disappear. As a rule the bony deformities, such as epiphyseal enlargement, diminish with growth, but remain through life to a certain degree. It may be mentioned that in reading treatises on rickets by English writers, the American reader must make allowances for the greater severity of the disease in the English climate.

Treatment.

The preventive treatment of rickets consists simply in the proper feeding of any child whose surroundings are not positively bad. It has been seen that rickets almost never develops without sufficient dietetic cause, and its prevention consists, therefore, in giving suitable food to each child.

For what this food should be the reader is referred to works on the diseases of children. In addition to this diet it is desirable to give to rhachitic children of over six months meat juice or raw beef in small quantities and orange or lemon juice.

The earlier in the disease the case is seen the more important is the regulation of the food. In cases in which the process is nearly ended, it matters little what the child eats except in so far as it influences his general condition.

Drug treatment is manifestly secondary in importance to careful regulation of the diet and hygiene.

A remedy much advocated in the treatment of rickets is phosphorus, and especially is this extolled by German writers who ascribe to it almost a specific action. It is given in doses of $\frac{1}{100}$ to $\frac{1}{150}$ of a grain three times a day, and in two or three weeks it is said that marked improvement may be seen.[1] It is administered in cod-liver oil, but is also available in pill form, or it may be dissolved in sweet almond oil[2] or alcohol diluted with glycerin.

Lime is a remedy very much advocated in the treatment of rickets, and it is generally given in combination with phosphoric acid, either as powdered phosphate of lime, or the syrup of the hypophosphites, or syrup of the lacto-phosphate. Its use rests rather upon a theoretical than an empirical basis, and one is apt to be disappointed in its working as a drug. It is, however, desirable to administer lime in the food in

[1] Toeplitz and Kassowitz: Cent. f. Chir., 1887, No. 10.

[2] Zeit. f. klin. Med., 1883, vii., 36.

some way during convalescence; but the administration of lime water seems of little use unless there is reason to believe that the contents of the stomach are unduly acid. Parrish's chemical food is an acceptable and efficient way of giving lime.

Cod-liver oil is of use both alone and in connection with other treatment. One method of administration is to have the oil rubbed into the legs and abdomen each night with the warm hand. The method is not objectionable if the oil is carefully washed off in the morning.

The use of wine or spirits in small quantities is advisable in the case of children whose general condition is poor and whose circulation is feeble.

Finally one finds a long list of drugs which are advocated by various writers.

The complications of rickets are to be treated much as if they were independent affections.

Hygiene and General Surroundings.—Rhachitic children should be bathed daily, preferably in salted water, and rubbed vigorously. Warm woollen clothing should be worn and they should go out daily. Especial care should be taken to keep them in sunny, well-ventilated rooms; their meals should be regular, and they should be obliged to eat slowly. The bowels should be watched and kept regular; and every care should be paid to keeping the child's general condition as good as possible in every way. The seashore hospitals, now established in Italy, France, Germany, and America, provide, with proper nursing, air, and food, the best prophylactic against rickets. In some of the large cities in Italy, institutions similar to those in America known as "day nurseries" have been provided for the daily reception and treatment of rhachitic children, with proper arrangements for bathing and fresh air. Marked improvement is reported in the cases treated in these institutions.

The discussion of the operative and mechanical treatment of rickets will be taken up under the head of knock-knee and bow legs.

Osteomalacia.—Osteomalacia is a process somewhat similar to rickets, also occasioning softening of the bones, occurring most often in adults but occasionally in children. It is the disease at one time spoken of as "senile rickets."

Of the cause of osteomalacia nothing definite is known. It occurs generally in women, often in connection with pregnancy. It is far more frequent in certain localities than in others. The characteristic change in the process is a softening of the bones similar to that in rickets, but the pathological condition is different. There is absorption of lime salts beginning first at the medullary cavity and proceeding outward; the epiphyses are not notably affected. In rickets, it will be remembered, the chief pathological changes occur at the epiphyses. In osteomalacia the medulla resembles that in infancy in gross appearance, due to an

infiltration of round cells, loss of fat, and a hyperæmia.[1] By the continuance of the absorptive process the cortical bone becomes spongy and decalcified, and in the severest cases there may remain little but marrow and periosteum.[2] Of course, in this condition the bones may be deformed to a very great degree. The milder forms of the affection are, of course, much more common than these extreme grades. Most of the pathologists are of the opinion that in osteomalacia the layer of "osteoid tissue" results from decalcification, while in rickets a similar layer represents a new growth deficient in lime salts. The periosteum is likely to be thickened and vascular.

Spontaneous fractures may occur as a symptom of osteomalacia, but other causes of such fractures exist in the condition known as osteopsathyrosis which is often hereditary. In osteomalacia when such fractures occur union may occur or false joints may be the result. In all spontaneous fractures union may of course occur at a vicious angle.

The most familiar bony deformity in osteomalacia is distortion of the pelvis, the leg bones may bend and bow legs or genu valgum may be found. The thorax is flattened laterally and fractures of the ribs may occur. The changes in the spine have been alluded to in Chapter III. The condition of osteomalacia has been reported in children.[3]

A treatment proposed and carried out in a number of cases consists in the removal of the ovaries. Phosphorus is said to be of much value in certain cases.

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[1] Ziegler: "Path. Anat.," vol. ii.

[2] Warren, J. C.: "Surg. Pathology," p. 598.

[3] Rehn: Jahrb. f. Khde., 1878, xii., 100, and 1883, xix., 171; Siegert: Münch. med. Woch., xlv., November 1st, 1898; Griffiths: Tr. Am. Assn. Physicians, 1896, xi., 121.

CHAPTER XVIII.

KNOCK-KNEE AND BOW LEGS.

Knock-knee. — Occurrence and etiology. — Symptoms. — Diagnosis. — Prognosis. — Treatment. — Expectant. — Mechanical. — Operative. — Bow Legs. — Occurrence. — Causation. — Symptoms. — Diagnosis. — Prognosis. — Treatment. — Expectant. — Mechanical. — Operative.

Knock-knee.

Knock-knee, or *genu valgum*, is the name applied to an internal angular prominence of the knee, in which the bones of the leg form an abnormal lateral angle with the bones of the thigh, and this angle opens outward.

This condition is also known in English as in-knee; in Latin as genu introrsum; in German as Knickbein, X-bein, Bäckerbein, Ziegenbein, Kniebohrer, Knieng, and Schemmelbein; in French as genou cagneux, genou en dedans, and in Italian as ginocchio torto all' indentro.

Occurrence and Etiology.—The deformity is one of common occurrence, but not so common as bow legs. In 7,900 cases of surgical disease in children coming to the Out-Patient Department of the Boston Children's Hospital there were only 218 cases of knock-knee, while there were 427 cases of bow legs. In 6,400 cases of surgical disease in children treated at the New York Orthopedic Hospital and Dispensary there were 270 cases of knock-knee and 400 cases of bow legs; and in general this relative frequency holds good. Both deformities affect boys more often than girls.

Knock-knee is a deformity which becomes evident in early childhood or at adolescence. In rare cases it has been noted at birth, but it appears for the most part shortly after the children learn to walk, although by no means is its appearance necessarily delayed until that time—for the deformity is sometimes seen in infants in arms; but always in these cases it is associated with general rickets. Its regular appearance, then, is at one of two distinct periods: between the ages of two and four, or between the ages of twelve and eighteen. Exceptional cases occur at any age.

Knock-knee occurring in the first period named is almost always associated with general rickets, and no obscurity exists as to its cause, and this is spoken of by many writers as *genu valgum rhachiticum*, to distin-

guish it from the form occurring at puberty, which is spoken of as *genu valgum staticum sive adolescentium.* Many efforts have been made to

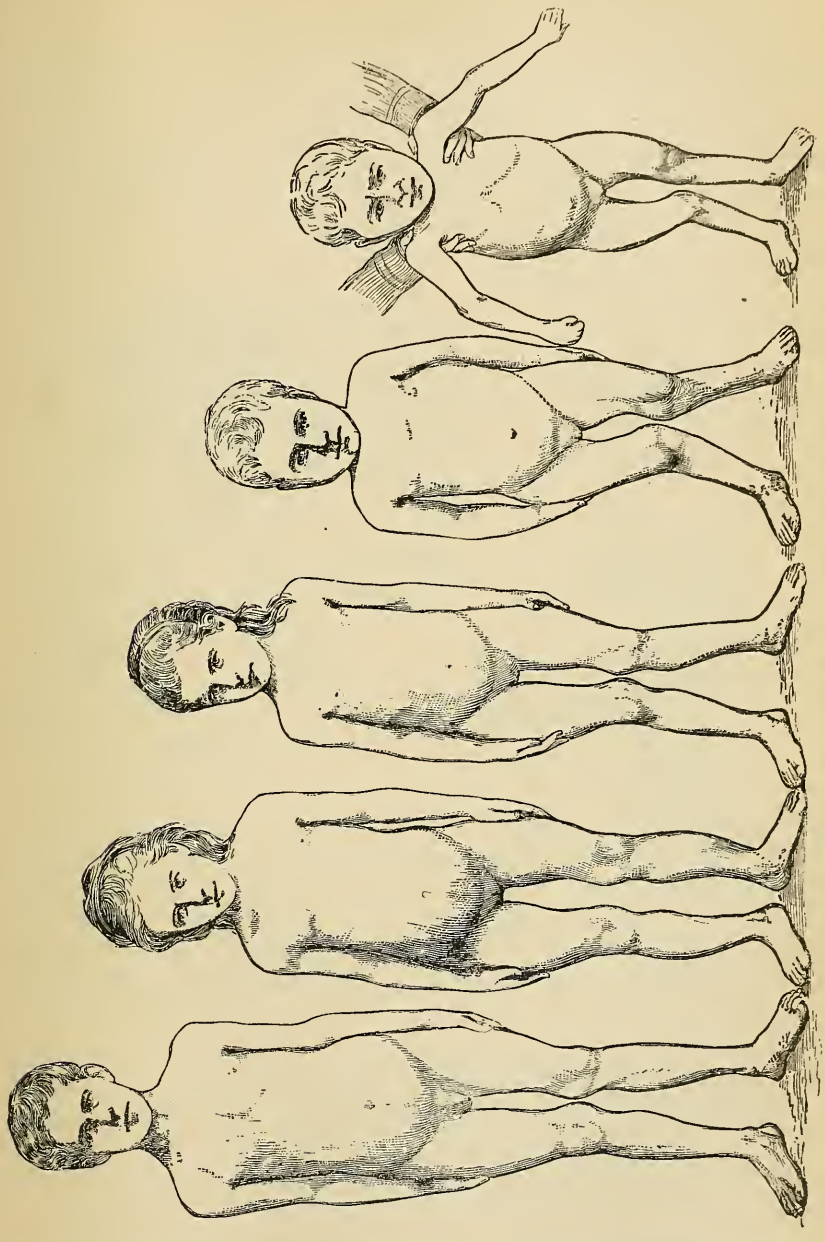

FIG. 498.—A Family of Five Children with Varying Degrees of Knock-knee. (Roberts.)

identify this later form also with rickets, as by Mikulicz and others, who would consider it a local rhachitic process, a form of "latent rickets."

The form of knock-knee occurring in adolescence especially affects persons whose occupation compels them to be most of the time in a standing position, and, as a rule, those affected are individuals of feeble physique.

Other cases of knock-knee are produced as a late result of muscular paralysis. Fractures about the joint and destructive ostitis are also causes of knock-knee in exceptional cases.

How these pathological factors find their clinical expression in an angular deformity of the knee will be considered in the following section.

Mechanical Production of Knock-knee.—The normally formed human being in the upright position stands with a certain amount of knock-knee.

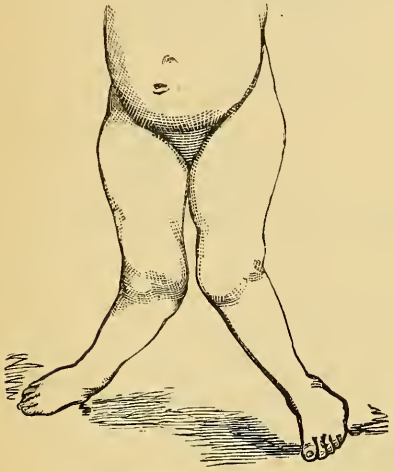

FIG. 499.—Severe Knock-knee.

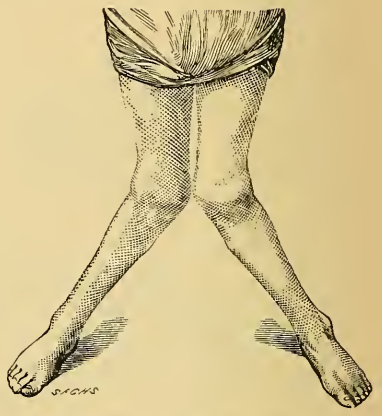

FIG. 500.—Severe Knock-knee, with Outward Rotation of Tibia.

The femurs form an angle of 15° with each other and sometimes more, and as a result of this oblique direction, the inner condyle of the femur must be longer than the outer. This is evident from a glance at the figure. This excess of length must vary with the width of the pelvis and the obliquity of the femurs. Clark estimated that the internal condyle of the femur was normally longer than the external by a quarter of an inch, and Holden estimates it as one-half an inch longer under normal circumstances.

The chief cause of the deformity seems to be a static one, except in those early cases due to rickets in which weight has not been borne upon the feet. Here its cause lies in an unequal growth of the epiphysis of the femur or in a bend of the lower part of the shaft of the femur or the upper part of the tibia produced by great softness of the bone and muscular action pulling upon the bone and causing it to curve.

When a normally formed person stands erect with the heels together, if a plumb line be dropped from the head of the femur it will be seen

to fall outside of the centre of the knee-joint; and this will happen to a greater extent in the female than in the male.

It is therefore evident that the external condyle of the femur and the corresponding facet of the tibia transmit more body weight than do the corresponding internal articular surfaces, because the centre of gravity lies outside of the centre of the joint.

To maintain an erect position with the feet together requires, therefore, muscular action. If the standing position is to be maintained for a long time, or for a short time in the case of children or feebly developed adults, the instinctive disposition is to substitute ligamentous for muscular support. This can be accomplished by

Fig. 501.—Rhachitic Knock-knee.

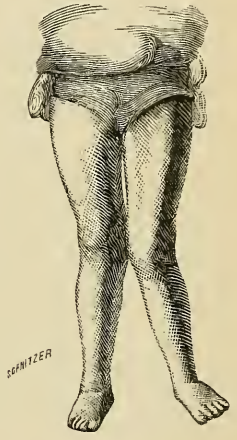

Fig. 502.—Slight Knock-knee (Chiefly on Left) with Flat-foot.

keeping the knee extended and separating and everting the feet. It is the attitude assumed by children learning to walk and by tired adults. In this way the weight comes upon the knee-joint laterally, and muscular effort is not needed to keep the joint rigid in the lateral plane; for that is accomplished by the ligaments. This attitude is often spoken of as "the attitude of rest."

From this position more weight than before is transmitted through the external condyle, and less through the internal one. If angular deformity takes place, finally all the weight is transmitted through the external condyle.

Two results may follow from this: stretching of the internal lateral ligament and atrophy of the external condyle.

The stretching of ligaments when subject to undue tension is too familiar a pathological process to require comment. The atrophy of bone which is subjected to pressure and strain has been established clearly enough by Arbuthnot Lane.[1]

These factors tend, then, to produce and increase angular deformity at the knee. As the external condyle shrinks and the ligament lengthens, the angle between the bones of the thigh and the bones of the leg increases, and with each increase the body weight acquires better leverage and more power to do harm to the yielding joint.

Although the mechanical forces just alluded to are competent to produce severe knock-knee, the presence of rickets makes the condition much worse, for it not only softens the bones, but relaxes the ligaments and weakens the muscles. It is easy to see, therefore, how much this process would aid in producing the deformity of knock-knee, not only at the joint, but in the femur and the tibia, by allowing their shafts to bend above and below the joint, and so making the deformity excessive.

Flat-foot ordinarily coexists. Sometimes it must stand in a causative relation to knock-knee; sometimes it is more the result than the cause, but commonly they are both the results of the same faulty attitude, assumed as a result of muscular fatigue and weakness. Flat-foot is more easily produced than knock-knee, and is much more common.

It is proper to recognize the class of cases when the femur is apparently normal, but the articulating surfaces on the head of the tibia are oblique. This is considered as the common cause of the deformity by some writers.

In still a third class of cases the deformity is due not so much to primary joint obliquity as to a bend in the diaphysis of the femur or the tibia just above or just below the joint.[2]

There are, then, three bony deformities likely to be found in cases of knock-knee, viz.:

(*a*) Difference in the size of the condyles of the femur.

(*b*) Inequality in the articular facets of the tibia.

(*c*) Bending of the diaphyses of the bones above or below the joint.

In severe cases the tibia is found to be rotated outward.

The internal ligaments are hypertrophied, and the muscles and tendons on the inner aspect of the leg are, of course, stretched. The patella lies farther outside than it should do. In some it may be seen that the outward rotation of the tibia is so marked that a sort of compensatory inversion of the feet has been acquired almost to the condition of varus to aid in keeping balanced.

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[1] Lane: Guy's Hosp. Rep., vol. xxviii. [2] Arch. f. klin. Chir., 1879, xxiii.

The deformity is due to the yielding of ligaments and bone at the knee-joint. It occurs in connection with general rickets and in cases in which general rickets cannot be demonstrated but in which undue softness of bones and ligaments must have existed.

Mikulicz would find the cause in hyperextension of the tibia and consequent exaggerated external rotation of that bone.

Symptoms.—Subjective symptoms in knock-knee are almost always absent. Children and adults tire more easily than they should when

FIG. 503.—Child with Loose Ligaments Standing "at Ease."

FIG. 504.—Same Child Standing "at Attention." (Children's Hospital Report.)

they have knock-knee, and sometimes pain and sensitiveness are complained of over the internal lateral ligament of the knee; as a rule those with knock-knee are clumsy and have a poor sense of balance. But this is not commonly noticed. In young children with knock-knee and active rickets locomotion is generally difficult, while in adult cases there is less difficulty in walking, even in severe cases, than would be expected from the degree of the deformity.

In the standing position it is noticed that the knees are unduly prominent on the inside aspect of the leg, and that the tibiæ diverge so that

the feet are, perhaps, only a few inches apart, or again, in severe cases, a considerable distance. In cases in which the angular deformity is very great, the patients find the easiest position for standing is with one knee behind the other, so that in this way the feet may be brought together.

If the child stands with the feet together one knee is generally a little hyperextended and the other slightly flexed so that they apparently come together.

Hyperextension of one or both knees and outward rotation of the tibia are common accompaniments of knock-knee.

The gait of a patient with double knock-knee is distinctive. Inasmuch as the knees overlap when the feet are together, some means must be adopted, on the patient's part, to prevent the knees from knocking

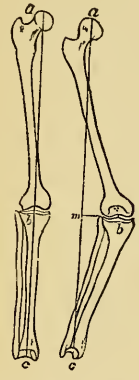

FIG. 505.—Axis of a Normal Leg, and of one Affected with Knock-knee.

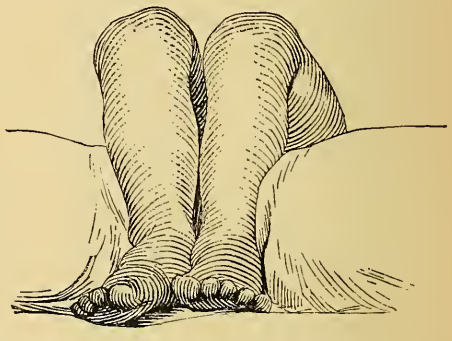

FIG. 506.—Inequality of the Condyles, shown in Outline in a Case of severe Knock-knee.

against each other as he carries one leg forward past the other in walking. If he walked naturally, the knee that was behind would hit against the front knee and stop progression. This can be avoided by throwing his body to one side while he abducts the opposite leg, and so carries it past the stationary leg without knocking the knees together. This must be repeated at each step, so that the gait is a rolling one, consisting of a series of slight lurches, which are, however, not nearly so marked as in bow-legs or congenital dislocation of the hip; while what is particularly noticeable is the outward throw of the leg when it is being brought forward.

The gait is, moreover, slightly modified by the fact that in severe cases the thighs and consequently the knees are slightly flexed. "Toeing in" is common, even in the slighter grades.

When the deformity is unilateral, the limp is much less marked. The affection of the gait is generally very slight in these cases. Lateral curvature is sometimes induced by the unilateral deformity, especially as

the knock-knee is likely to occur, as we have seen, in patients whose muscular development is feeble.

On manipulation, the knee-joint is often movable in a lateral plane through an arc of several degrees. In these cases the deformity is, of

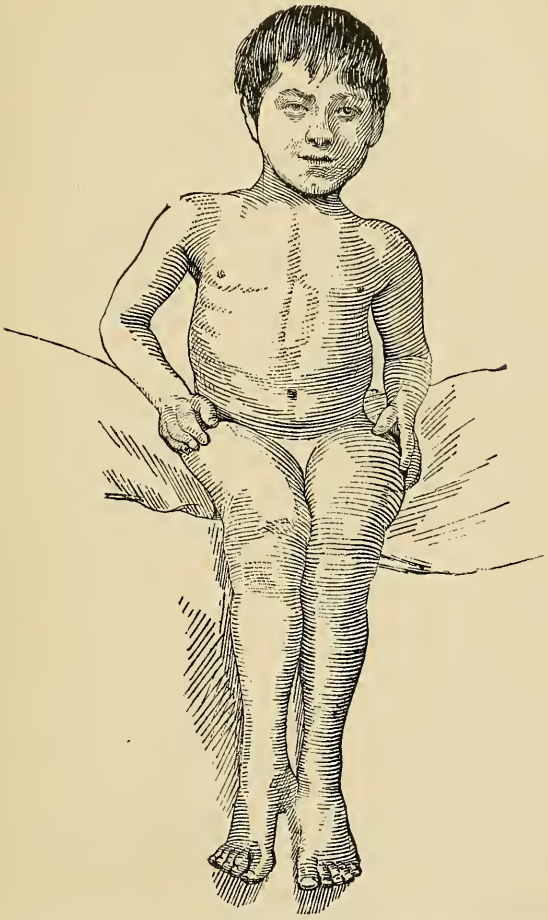

FIG. 507.—Showing Disappearance of Deformity when Knee is Flexed.

course, increased when weight is put upon the affected leg, so that in walking and standing it reaches its maximum.

The angular deformity disappears when the knee is flexed to a right angle, except in cases in which the chief twist is in the tibia. But if the knee be flexed while the hip-joint is still extended, the deformity does not entirely disappear, though it is very much diminished.

The practical point is, that as the deformity is most severe when the leg is in the extended position, all mechanical treatment applied to the

correction of knock-knee must be to the fully extended leg, for when apparatus allows the knee to flex, it is imperfect, and loses a part of its efficiency. When the leg is fully flexed the inequality in the length of the condyles is most evident, as seen in outline from the anterior surface of the thigh. This may be registered by shaping a lead strip to the lower surface of the femur when the knee is fully flexed, and drawing an outline on paper from the lead strip, which should be stiff enough to keep its shape (see Figs. 506 and 508).

Secondary Deformities.—Beside lateral curvature and flat-foot there is seen at times a condition of the foot approaching varus in certain advanced cases of knock-knee in which the deformity is severe and a continual effort is made to invert the feet and so bring the support nearer the centre of the body. By this means a permanent inversion of the front part of the foot may be acquired (see Fig. 519).

Occasionally one sees a combination of knock-knee and bow legs in the same subject.

FIG. 508.—Tracing of Case of Knock-knee with Outline of Condyles.

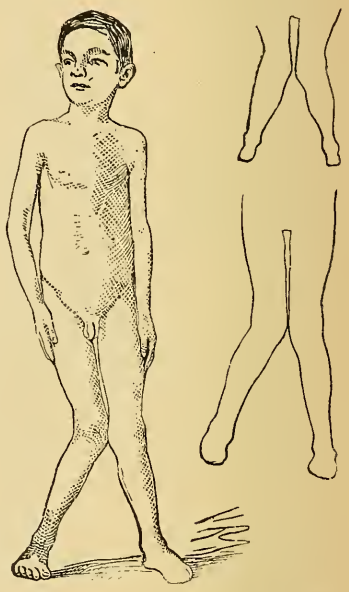

FIG. 509.—Case of Knock-knee, Showing also the Tracings of the Legs at an Interval of Four Years with no Treatment.

Measurement of the Deformity.—The simplest and most reliable method of registration is to have the patient sit upon a sheet of brown paper with the legs extended and the feet pointing upward; and then, with a pencil held perpendicularly to the paper, to trace the outline of the legs. No other method can give so accurate an idea of the degree and character of the deformity present, or can afford so delicate a means of watching and recording the progress of the case.

Diagnosis.—The diagnostic points which mark the affection known as knock-knee are an inward angular deformity at the knee which disappears on flexion of the leg upon the thigh. There is also in the latter

position to be noted a relative prominence of the internal condyle of the femur in nearly all cases.

In children the large proportion of all cases are rhachitic and static, while in adults the purely static cause must be assigned. It is not in general justifiable to assume rickets as the cause of knock-knee in cases in which there are no distinctive signs of rickets.

Paralytic knock-knee occurs only in severe grades of paralysis. Its diagnosis is evident from the wasted and contracted condition of the paralyzed limb.

Knock-knee from destructive disease of the knee-joint is a result of severe tumor albus and not of the lighter grades.

Traumatic knock-knee is of two kinds: (*a*) Resulting from osteotomy for genu varum and over-correction of the deformity; (*b*) resulting from fractures of the condyles of the femur or of the articular facets of the tibia, which are liable to cause lateral malposition of the knee.

Prognosis.—In severe cases it is evident that so much harm has been done already, and the bones have come into such faulty apposition, that spontaneous improvement is not to be expected. Children with a slight degree of knock-knee which is not progressive will probably outgrow it without any treatment if in vigorous health. But if the deformity is moderate or severe, the chances are strong that the affection will remain stationary or more probably will become worse as time goes on, unless active treatment is begun.

Treatment.—The treatment of knock-knee falls into three divisions: (I.) Expectant; (II.) Mechanical; (III.) Operative.

I. The expectant method of treatment relies upon nature's efforts to repair the deformity; efforts which are aided on the part of the surgeon by keeping the child off of its feet to a greater or less extent, and by constitutional treatment and by massage. In mild cases there is a tendency to outgrow the deformity, but this tendency is at a great disadvantage mechanically; nor is it a safe proceeding to wait for this spontaneous cure in any marked case of knock-knee. The difficult question in the whole matter is to decide which cases can be left to themselves—a question which cannot be answered categorically.

An argument for the spontaneous outgrowth of knock-knee is found by some writers in the rarity of adult cases which present themselves at clinics. Gibney[1] observed in six years 276 cases of genu valgum at the Hospital for the Ruptured and Crippled; and 255 were in children below fourteen years of age. This scarcity of cases in older persons is noted in all hospital clinics, but it is not altogether a trustworthy observation upon which to depend, because the class of adults who would be likely

[1] Gibney: N. Y. Med. Journ., November 29th, 1884.

to come to such clinics would attach but little importance to a deformity which practically caused them no inconvenience.

Whitman[1] attacked the same question from a slightly different standpoint by counting the proportion of persons with knock-knee among adult males, taken consecutively as he met them in the streets of Boston. In 2,000 adult males he observed 32 cases of knock-knee, and although it is impossible to state even approximately the proportion of knock-knee children, he calls attention to the fact that it is not likely to be larger than this. From his observations, therefore, he would conclude that there

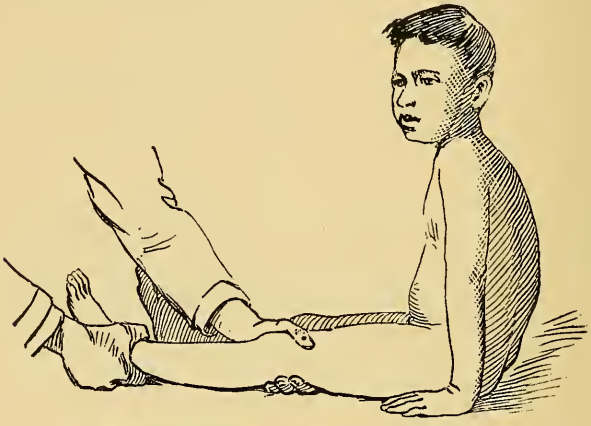

FIG. 510.—Manipulation in the Treatment of Knock-knee.

was not a very great tendency in children to outgrow this deformity. Noble Smith, several years ago, reached practically the same conclusion, making observation upon adults among the English artisan class.

It is said[2] that the tendency of slight knock-knee is very strong toward recovery if the body weight is taken off of the affected joint. It may be remarked that no treatment is harder to carry out practically than this.

When the expectant method is chosen in rhachitic knock-knee, the child should at once be put upon the constitutional treatment for rickets. If the knock-knee is merely the outcome of a feeble general condition, the patient should be most carefully looked after in the matter of hygiene, and tonic treatment and gymnastics should be given, the aim of which should be to strengthen the leg muscles. As much as possible the patient should be kept off of the feet, and a change to country air is capable of effecting great local improvement in feeble children.

The legs should be rubbed and manipulated each night. The rubbing

[1] N. Y. Med. Record, July 30th, 1887.

[2] Liverpool Med.-Chir. Journ., January, 1887, 119.

should be the same as that described under infantile paralysis, and the manipulation, in cases of knock-knee, should be directed to the gentle correction of the deformity by repeated mild manual pressure. With one hand the manipulator presses the knee outward while with the other he presses the lower end of the tibia inward. Even with a very slight degree of force a certain yielding can be felt in the direction of improvement, and then the pressure should be relaxed and the limb allowed to resume its first position. This manipulation should be repeated many times, continuing each pressure only a few seconds. Nor should it ever be done forcibly or long enough to make the child cry. This manipulation faithfully carried out is an important adjuvant, not only of expectant but of mechanical treatment.

FIG. 511.—Bow-leg of Right Leg, Knock-knee and Flat-foot on Left.

But little harm is done in applying splints to a child who might possibly improve without them, but a great deal of harm may be done by allowing the deformity to increase because splints are not applied. In no case should expectant treatment be considered when the child is not under sufficiently close observation to be seen every few weeks, and to have tracings taken to determine whether the deformity is improving or is stationary.

II. *Mechanical Treatment.* — Treatment by apparatus aims at the gradual correction of the deformity, commonly by making counter-pressure against the internal condyle to prevent the further giving way of the knee and to pull it outward to a fixed point furnished by an outside upright. Upon this principle all modern apparatus is constructed.

Another method which partakes largely of the expectant plan is one spoken of by Rushton Parker, which the writers have tried experimentally. It is based upon the interdependence of flat-foot and knock-knee, which suggests the treatment of knock-knee by correcting the flat-foot, either by the device of Mr. Thomas, who raises the inner side of the foot by sloping off the sole of the boot toward the outer side, or by some of the various forms of sole plate which elevate the arch of the foot, and so induce a more correct position in standing. Practically it is possible to improve the condition of flat-foot very much while the knock-knee becomes worse or remains stationary. The plan of treatment is not one which can be relied upon.

In children in whom the change known as eburnation has succeeded rickets, the bones are so hard and unyielding that it is almost hopeless, by means of such mild traction as can be exerted, to pull the knee back into place. Whether or not this eburnation is present is often a difficult matter to decide, and one is obliged to depend upon the age of the child and the resistance offered by the bones on manual pressure. In general terms, it is not probable that mechanical treatment will be of use after the age of four years has been reached except in slight cases; nor is osteotomy or osteoclasis likely to be considered before that time. Under this age in moderate degrees of deformity the outlook is good with mechanical treatment, and the younger the patient the better the outlook.

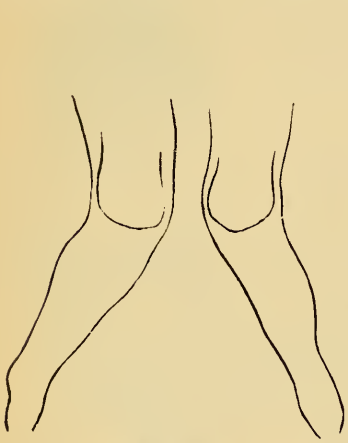

FIG. 512.

FIG. 513.

FIGS. 512 and 513.—Knock-knee. Mechanical treatment for one and one-half years.

The aim of mechanical treatment is to cause atrophy of the internal condyle, with overgrowth of the external one, so that the plane of the knee-joint may once more become normal. Simply to stretch the external lateral ligaments, without altering the relation of the condyles, would result in a laterally movable joint.

Former orthopedic methods are exemplified by methods of recumbency, a method which has practically become obsolete.

In the ambulatory treatment of the affection the form figured has been in use for some years at the Children's Hospital, and has proved itself efficient in practical use. It is a light steel rod attached below to a steel sole plate and jointed at the ankle. It runs up the outside of the leg as far as the trochanter, and then the rod is bent backward and upward, as the figure shows, to lie against the upper part of the buttock and to serve as an arm by which the legs can be everted if the child toes in in walking. Or the shaft may be carried up to the trochanter and finished in a curved horizontal arm following the ilium, with a joint

opposite the hip. The knee is drawn upon by a square leather pad, pulling from the shaft opposite the knee. The upper ends of the apparatus should be buckled together posteriorly by two straps, one connecting the tips of the posterior arms, and sometimes another may be needed running across the lower abdomen, connecting the shafts; by lengthening and shortening these straps it is evident that any desired degree of inversion or eversion of the feet may be produced. Often the posterior strap alone is all that is needed.

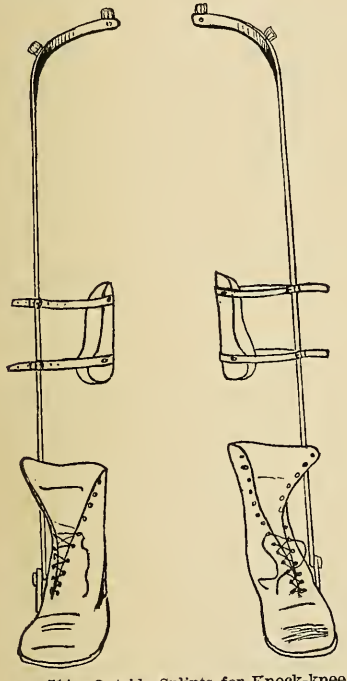

FIG. 514.—Outside Splints for Knock-knee.

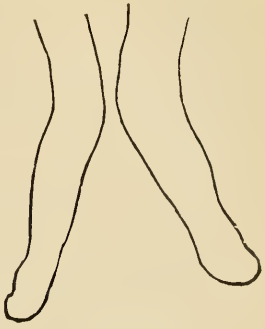

FIG. 515.

FIG. 516.

FIGS. 515 and 516.—Knock-knee Cured in Three Years by the use of Simple Outside Upright. A good average result.

A cheaper and simpler apparatus is mentioned by Noble Smith, consisting of two straight outside wooden splints, attached together at the top by a band to encircle the posterior half of the pelvis, and below strapped to the ankles by a broad piece of webbing. They run down the outside of the legs and the knees are pulled out to them.

There is no advantage in carrying the outside uprights to a rigid waist band as is done sometimes.

In the older methods of treatment, long continued, with recumbency in bed, successful cures have been reported in patients much older than

would be subjected to mechanical treatment in the practice of modern orthopedic surgeons.

III. *Operative Treatment.*—The modern operative treatment of knock-knee is comprised under the simple operations of osteotomy and osteoclasis. Division of the outer ligaments and tendons of the knee and Delore's redressement forcé belong to the surgery of the past.

Osteotomy.—The operation consists in the division of part of the bone by the chisel, and the completion of the procedure by fracture of the partly divided bone.

The operations all have much the same aim and differ only in detail; their object is one of these three things:

(1) Separation of the internal condyle and its displacement upward.

(2) Section of the upper end of the tibia and perhaps the fibula.

(3) Section of the femur above the condyles.

The operation of osteotomy performed with antiseptic precautions is not one which is attended with any special risk. Macewen, in 1884, had done osteotomy for genu valgum 820 times,[1] with 5 deaths; and in no case was death to be considerd as directly traceable to the operation—the patients dying of pneumonia, measles, etc. Collecting the cases of other British surgeons he had, with his own 820, 1,384 cases of knock-knee operated upon by his method, with 3 deaths due to operation, 2 of which were caused by septicæmia and the cause of the third is not stated.

Accidents from carefully performed osteotomy have, however, been reported. Howard Marsh[2] wounded the anastomotica magna artery in performing Macewen's operation, and a few days later was obliged to cut down on it and tie it. McGill[3] reported a case in which the popliteal artery was divided and had to be ligatured. Gibney[4] reported a case of severe hemorrhage from the bone and speaks of it as the only severe hemorrhage that he has ever seen from the operation. He also mentions another case of which he knew, in which the anastomotica artery was wounded. Fatal bleeding has resulted from the operation,[5] and Langton[6] reports death after amputation of the thigh on account of gangrene, consequent upon ligation of the popliteal artery which had been punctured by a sharp spicule of bone projecting from the lower fragment.

The external peroneal nerve has been divided, and doubtless a number of accidents which have occurred have never been reported; but the writers in a large number of cases in their own experience and that of

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[1] Macewen: Lancet, September 27th, 1884.

[2] Brit. Med. Journ., 1884, i., 665; Lancet, May 17th, 1884, p. 891.

[3] McGill: Lancet, May 17th, 1884.

[4] N. Y. Med. Journal, December 6th, 1884.

[5] Phila. Med. News, November 1st, 1884.

[6] Lancet, March 29th, 1884.

their colleagues, have known of no accident in the performance of Macewen's osteotomy.

In 525 operations by Ogston's method there were 13 hemorrhages of considerable severity, while in 580 osteotomies done by Macewen's method there were only 2 cases of such bleeding.[1]

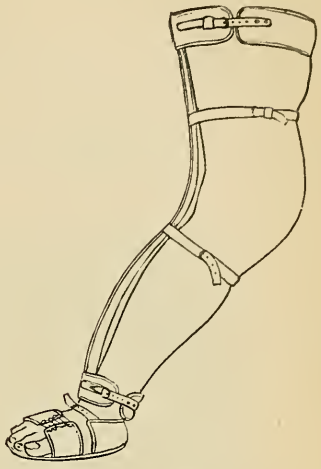

FIG. 517.—Roberts' Elastic Traction Brace for Knock-knee.

Macewen says that hemorrhage which occurs in the performance of the operation as described by him is due to one of the following mistakes: the use of too broad an instrument; not cutting the posterior part of the bone with the chisel pointed forward and outward, but allowing the chisel to point backward; holding the osteotome loosely and letting it slip during the cutting.

The osteotome should be marked on one side of the blade with lines one-quarter of an inch apart to show how deeply the edge has penetrated. It is very convenient to have two breadths of osteotome, one three-eighths of an inch wide, the other five-eighths or three-quarters of an inch wide. They should be about six inches long; but if only one width is practicable it should be half an inch wide.[2]

The operation of Macewen has superseded all other operations for the correction of knock-knee.

Macewen's operation is performed as follows: the patient's leg is rendered aseptic; the patient lies on his side with the leg extended, the outer side of the knee resting on a sand-bag. The skin and underlying tissues are then divided with a knife over the point of division of the bone, or, what is more simple, the chisel is driven through the sound skin into the bone without any incision. This diminishes the bleeding and simplifies the operation. The use of an Esmarch bandage is unnecessary.

The point selected for operation is at the inner side of the thigh, half an inch above the abductor tubercle of the femur. The osteotome is driven into the bone with the blade at right angles to the long axis of the femur, and by successive blows with the mallet the operator cuts nearly through the whole thickness of the bone. The osteotome is likely to become wedged very firmly unless the precaution is taken to move the handle of the chisel laterally after each blow. In this way alone can one

[1] Brit. Med. Journ., June 30th, 1888, p. 1377. [2] Lancet, April 21st, 1889.

cut from the front to the back of the bone, for driving the chisel straight through in one line accomplishes but little. When the chisel has disappeared to a depth indicating that three-quarters of the bone has been divided, it should be withdrawn and an attempt made to fracture the thigh by gentle bending. If this cannot be done, the osteotome should cut further, for the common mistake is a failure to divide the anterior and posterior borders of the femur.

When the bone has broken, manipulation should be avoided except to put the leg in a corrected position, and, after an aseptic dressing has been applied, a plaster-of-Paris bandage should be put on to hold the leg in a

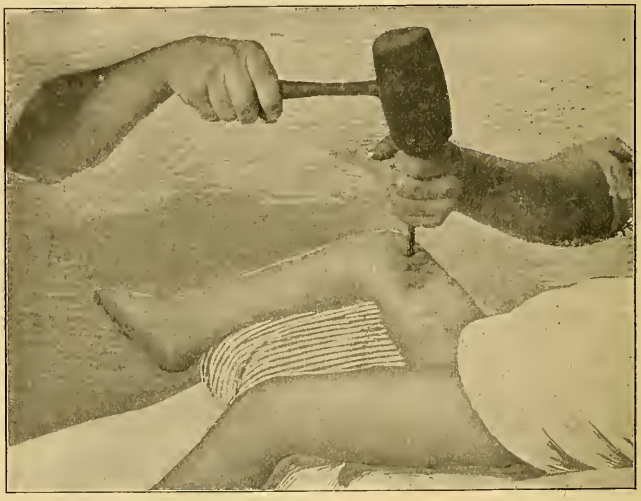

FIG. 518.—Macewen's Osteotomy for Knock-knee.

corrected position. Slight pain, if any, follows the operation and there should be no fever. No change of dressing is needed; the plaster may be removed in three or four weeks, and in six weeks or less the patient allowed to stand on the limbs.

Hahn, in an article on the treatment of genu varum and valgum, advocates the performance of osteotomy on the outer as well as on the inner side of the leg; in this way he thinks that he obtains greater precision in the location of the fracture than in chiselling the outer side of the femur alone.[1]

The corrected position of the bone is equally good whether the incision is made on the outer or the inner side of the shaft.

The result of osteotomy at the point of division of the bone was shown in a specimen described by Dr. A. T. Cabot[2] some years ago. He

[1] Berliner Klinik f. 10. April, 1889.

[2] Boston Med. and Surg. Journal, February 16th, 1883, p. 154.

had performed a Macewen operation and the child died in six weeks of typhoid fever. On the outer side of the bone the line of the shaft was well preserved; but on the inner side the compact wall of the shaft had been driven down into the cancellated tissue. In the centre the lower fragment was impacted into the upper, which locking, of course, resulted in great firmness. There was but slight callus formation and only a thin layer of bone under the periosteum on the outer side.

Macewen's operation is easier to perform than any other and is applicable to nearly all cases; it is so far removed from the joint that one avoids injury to ligaments and synovial membrane, and yet the line of section is near enough to the point of abnormal deviation to enable the deformity to be corrected by straightening the limb.

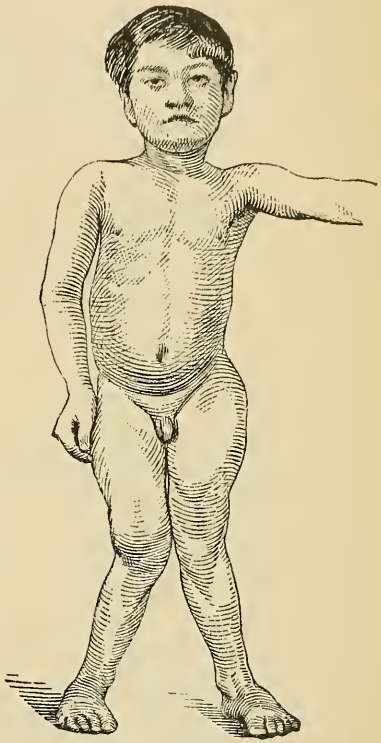

FIG. 519.—Severe Knock-knee, showing Especially the Inversion of the Feet.

The chief operation upon the condyles is Ogston's.

In the performance of Ogston's operation, a knife, which is small and sharp-pointed, is entered about two inches above the adductor tubercle of the femur, exactly in the middle of the inner surface of the thigh, and is then passed downward and outward across the front of the condyles until the point reaches the groove between the condyles, which is, of course, within the cavity of the joint. The knife is then withdrawn, being made to cut down to the bone on its way out. A narrow-pointed saw is then introduced through the incision and passed down under the patella until its point can be felt in the intercondyloid groove. The bone is sawed nearly through with short quick strokes until the posterior surface of the bone is nearly reached. The saw is then taken out and the limb straightened. An osteotome may be used instead of a saw. Except for very severe cases this operation has been superseded by Macewen's.

Thiersch[1] raised a formidable objection to Ogston's operation which applies equally well to all similar procedures. He called attention to

[1] London Med. Rec., June 15th, 1878.

the fact that the interruption of the epiphyseal cartilage might easily interfere with the growth of that part of the bone. Poore, of New York, saw a case in which this mishap had actually occurred. Two years after an Ogston's operation the left knee began to bend outward and walking became difficult.[1]

Sometimes when the deformity lies chiefly in the head of the tibia, the operation of osteotomy might be performed there either alone or in connection with femoral osteotomy. The removal of a wedge of bone is hardly necessary from either the femur or tibia in cases of knock-knee.

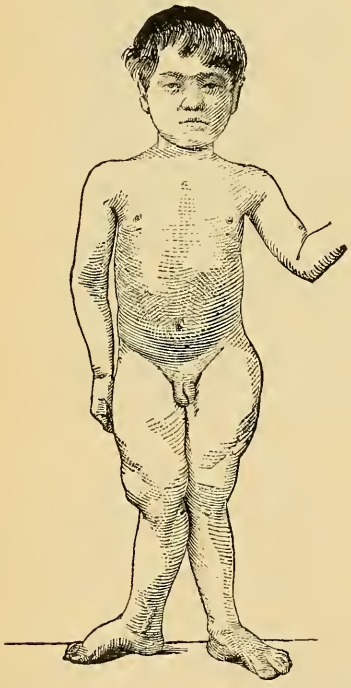

FIG. 520.—Position of Patient with severe Knock-knee in Walking.

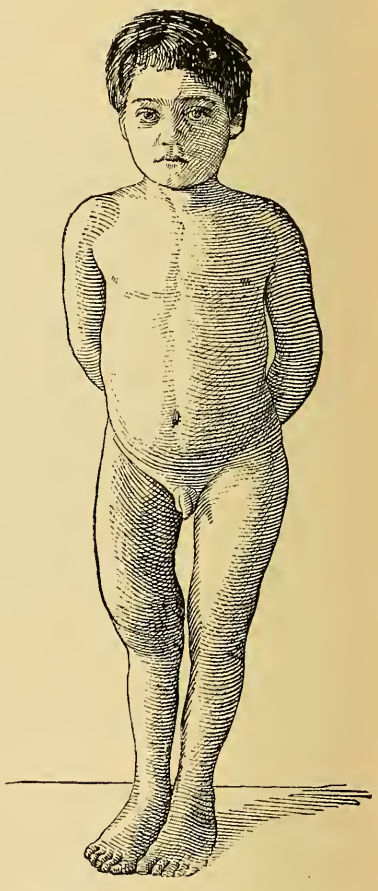

FIG. 521.—Same Case after Macewen's Osteotomy.

At the Boston Children's Hospital the Macewen operation is now performed to the exclusion of almost every other.

Osteoclasis.—The forcible fracture of bone by instrumental or man-

[1] Poore: "Osteotomy and Osteoclasis," New York, 1884, p. 100; C. T. Poore and others: N. Y. Med. Record, August 13th, 1881; Little: "In-Knee," Longmans and Green, London.

ual means in knock-knee is decidedly inferior to osteotomy, inasmuch as it lacks the precision of that method; more splintering occurs, and rupture of the external ligaments and epiphyseal separation are apt to occur, as in redressement forcé. It is, therefore, better to limit the use of osteoclasis to the correction of bow legs, where the instrumental or manual force can be applied to the shaft of a long bone.

The Collin osteoclast, however, breaks the bones with such precision that osteoclasis for genu valgum has been advocated, especially in France. Delens, who had given up osteoclasis for Macewen's osteotomy, returned to the performance of osteoclasis after seeing Collin's new osteoclast. Rollin and Molière described an osteoclast which could break the femur within two fingers' breadths of the joint, without affecting the articulation in any degree.[1]

Excision.—The operation of excision of the joint in paralytic knock-knee must be mentioned. Its advantage lies in the fact that it not only corrects the deformity but stiffens the affected joint, which is a great aid to those patients who are unable to wear apparatus.

Bow Legs.

Bow legs is the name applied to the opposite deformity to knock-knee, which is an outward angular deformity of the knee, or a general outward bowing of the legs, so that when the patient stands erect with the heels together the knees are a greater or less distance apart.

The condition is also known as genu varum, genu extrorsum, out-knee, bowed legs or bandy legs. In German one speaks of it as Säbelbein, Sichelbein, O-bein, and in French as Genou en dehors.

It is single or double, generally the latter, and may exceptionally exist in one leg when knock-knee is present in the other (see Fig. 511).

Occurrence.—The deformity is almost always the result of an outward yielding of the long bones of the leg, especially of the tibia. At times, however, it is clearly due to an obliquity at the knee-joint, where the external condyle appears the larger of the two.

The anatomical changes found are those of rickets. The bending of the bones is in most cases, like the other deformities of rickets, a simple yielding, without fracture or destruction of bone tissue.[2]

Causation.—Bow legs is essentially a rhachitic deformity in children, and true bow legs can occur only in a child whose bones are soft enough to bend easily. It occurs in the first three or four years of life, and ordinarily in connection with general rickets; sometimes, however, other

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[1] Cent. f. Chir., 1882, ii., 878; Bull. et Mem. de la Soc. de Chir., Paris, 1883, ix., 885.

[2] Kassowitz: "Die Symptome der Rachitis," Cent. f. Chir., 1887, p. 179.

rhachitic manifestations are absent; but the yielding of the bones in a child of this age must of itself be accounted sufficient evidence of rickets.

Bow legs of a marked type are seen in children who are too young ever to have borne their weight upon their legs. To account for them by any such pressure upon the bones as they would be likely to get from the mother's arm in a constantly changing position seems inadequate. The explanation is that the tonic action of the muscles of the legs has been sufficient to produce this. Muscular tonus is a most important factor in producing this deformity of the legs. Early walking, so much talked about as a cause of bow legs, is not to be accounted a factor of any importance in their production unless rickets in some degree is present.

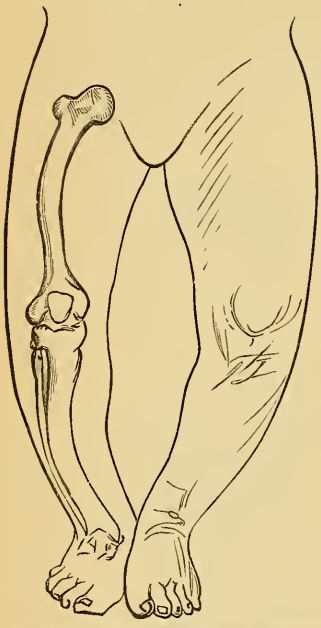

FIG. 522.—Shape of the Bones in Bow Legs.

Why the bones should bend outward as they do is a question which is by no means settled.

The child with rickets stands with thighs flexed and the lumbar spine arched forward; once given this condition it is easy to see how bow legs arise. As the thighs flex the knees are separated and the femurs rotate outward on their own axes; as a result of this the line of gravity, instead of falling outside of the knee-joint, as we have seen was the case in the normal erect position, falls inside of it; and any yielding of the bones of course must take place in the outward direction. With the yielding of the bones the line of the legs falls farther and farther outside of the line of gravity, and the body weight continually acquires better leverage to bend the bones.

Anterior curvature of the thigh and the leg bones is manifestly the result of body weight coming upon a flexed limb conjoined to the action of the most powerful muscles in the body (the flexor muscles of the thigh) pulling in the same direction.

Subjective symptoms are absent, except of course the symptoms of rickets. But the deformity is plainly evident, and even in the milder cases the gait is modified in a characteristic way. The child walks with a distinct waddle and generally with the feet wide apart and a tendency to invert the toes. The gait in bad cases bears a resemblance to the waddling gait of double congenital dislocation of the hips. The line of the leg lies so much outside of the line of the centre of gravity that in

bearing weight on the left leg, for instance, the body must be thrown decidedly over to the left to bring it over its line of support; it is in a measure the reverse of the gait in knock-knee. This lurching is inevitable with each step, and, other things being equal, is in a degree proportionate to the amount of curve present.

The deformity is almost always more conspicuous in the standing position, both because these children stand with the legs so far apart and

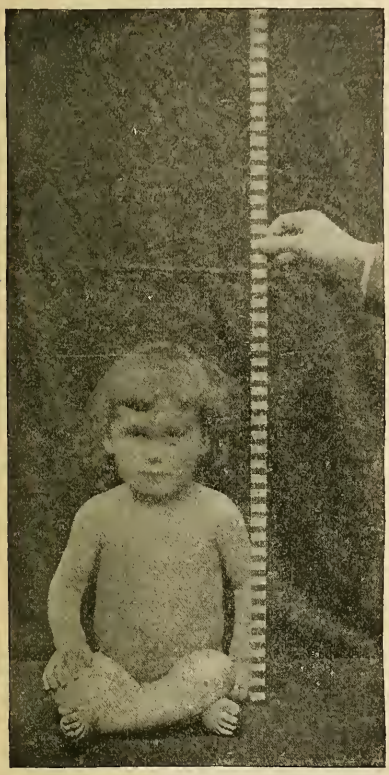

FIG. 523.—Child Sitting Turk Fashion, producing, at Junction of Lower and Mid-thirds of Legs, Anterior and Lateral Bowing. (Children's Hospital Report.)

FIG. 524.—Child with Bow Legs in Ordinary Sitting Position, Showing Fitting of One Leg to the Other. (Children's Hospital Report.)

because the knee-joints generally yield somewhat in a lateral direction when the body weight is superimposed.

The curve is most often a gradual and uniform bowing of the femur and tibia, so that with the feet together the outline of the legs forms an oval which, in severe cases, approaches a circle. A second class of cases presents a bowing chiefly in the lower third of the tibia which is more angular in character, and the femurs are practically normal; a third class presents, either alone or in conjunction with the other deformities, a bow-

ing forward of the tibia and sometimes of the femur also. These are the three common types of the deformity. At times the deformity lies chiefly in the knee-joint and the bones are comparatively straight.

Rarely one sees the condition of knock-knee and bow leg existing in the same leg.

The feet in cases of well-marked bow legs, like the feet of all rhachitic children, are in a condition of flat-foot in nearly all cases. They are inverted in walking.

The bones of children in the active stage of bow legs are thought to possess an abnormal degree of elasticity, a "springiness" it is

FIG. 525.—Standing Position of Child with moderate Bow Legs.

FIG. 526.—Curve involving whole Leg.

commonly called, and much importance is attached to this in determining whether or not the stage of eburnation has begun. One obtains this by grasping the upper part of the tibia and the knee-joint with one hand, while with the other the lower end of the tibia is pressed gently outward with a quick movement, and a sensation as if of an elastic yielding is felt. But it is doubtful how much importance should be attached to this, and to a certain degree the sensation is misleading and can be obtained in normal

limbs. One is not dealing directly with the bone, but with a bone embedded in soft and elastic-feeling muscles, and also it is impossible to hold the knee so tightly with the hand as to exclude the elasticity of the ligaments of the knee-joint when pulled upon.

Diagnosis.—The condition of bow legs is evident on inspection. Macewen's definition applied to this deformity would be, that it was a condition in which a line drawn from the head of the femur to the middle of the ankle-joint would fall inside of the centre of the knee-joint.

It is often difficult to determine how much of the deformity

FIG. 527.—Curve involving chiefly Tibia.

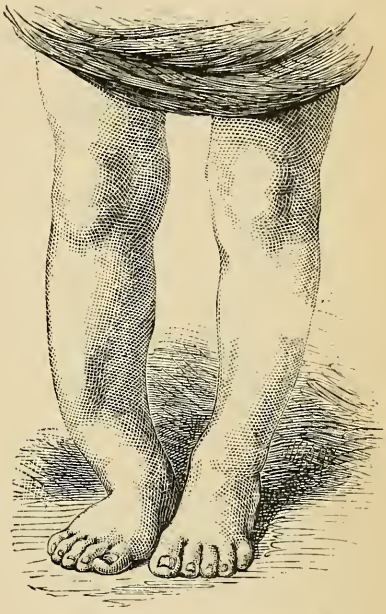

FIG. 528.—Anterior and Outward Bowing.

lies in the tibia and how much in the femur. If the legs are crossed until the insides of the knees are together when the child is in a sitting position, it will be seen whether the femurs include an oval space between them, or are parallel to each other.

Prognosis.—The prognosis in bow legs is favorable. The prospect of spontaneous outgrowth of the deformity is better than in knock-knee, and in young children rational mechanical treatment offers almost sure relief. The prognosis of bow legs, when untreated, will be considered more in detail in speaking of the treatment by expectancy. Mechanical treatment is not likely to benefit cases of anterior bowing except very

slight ones. Operative treatment can ameliorate almost any condition of deformity and often entirely rectify it.

Treatment.—The treatment of bow legs, like that of knock-knee, is to be considered under three heads: (*a*) expectant, (*b*) mechanical, (*c*) operative.

(*a*) *The expectant treatment* is suited to a large percentage of cases of the deformity, and its range of applicability is wider than in knock-

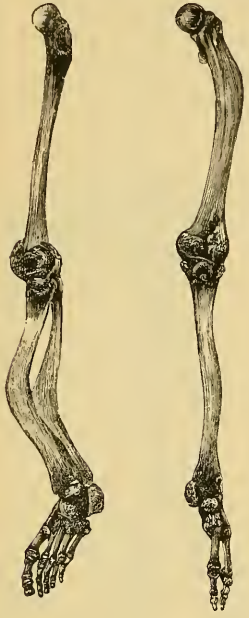

FIG. 529.—Anterior Curve of Femur and Outward Bowing of Tibia.

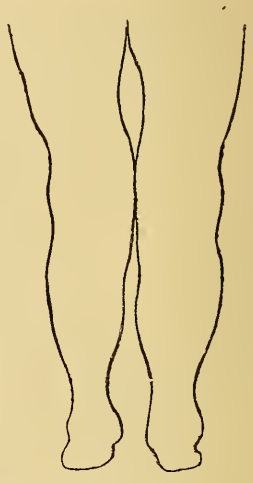

FIG. 530.—Spontaneous cure of Bow Legs.

FIG. 531.

FIG. 532.

FIG. 533.

FIGS. 531, 532, and 533.—Case of Bow Legs. Progress in three years under expectant treatment.

knee. The mechanical conditions are not so much in favor of the increase of the deformity as in knock-knee, and, if the osseous softening stops early enough, the tendency in slight cases is toward rectification in

the course of growth. In general, when the curve is uniform, involving femur and tibia alike, the chances are more favorable for spontaneous cure than if the deformity is localized in the tibia and more angular.

The difference between a gradual bowing of the legs and a sharp angular curvature of the tibia can be best appreciated by taking a tracing of the legs in the simple way already described.

The figures show some tracings taken at random from out-patient cases treated by expectancy, attending at the Children's Hospital. The parents were either unwilling to begin mechanical treatment or were negligent about it; but at the end of three or four years the children were sent for as a matter of curiosity; and two representative cases are presented in the figures. Neither of these had any treatment whatever, and there is no reason to believe that these are exceptional cases. In these cases mechanical treatment was advised when the children first came.

The number of men with bow legs to be seen in the streets as observed by Whitman was four hundred out of two thousand. It is evident, therefore, that not all cases of bow legs recover spontaneously. For this reason it is far safer to treat cases of bow legs of any severity by mechanical measures, always bearing in mind the fact that there is a likelihood of their complete recovery without any treatment whatever.

When the deformity is extreme or the bones are eburnated, it is not of course likely that the child will outgrow the bow legs. It is only in young children that one is justified in expecting it. Expectant treatment should be pursued only when the child can be kept under observation and tracings of the legs can be taken sufficiently often to see whether or not the deformity is increasing. Any increase of deformity is an indication for mechanical treatment.

During expectant treatment the general condition should be most carefully attended to and rickets treated very vigorously from the first. The child should be encouraged to be off of his feet as much as possible, and the legs should be rubbed and manipulated each night, being gently bent toward a straight direction.

In all cases tracings should be taken at least once each month, to determine if the deformity remains stationary or is improving, and if after two or three months no improvement is evident, mechanical treatment should be begun.

(*b*) *Mechanical treatment* is based upon the principle of drawing the knee inward to a rod which has counter points for sustaining outward pressure at the upper part of the thigh and at the ankle. Here, as in knock-knee, traction from a rigid rod is more definite and more satisfactory than from an elastic one. The form of apparatus used is of little consequence so long as it answers the indications and holds the knee extended. It is no longer customary to treat these cases by recumbency.

A simple padded inside wooden splint, to which the legs are bandaged, is advocated by Noble Smith.

The apparatus shown in Figs. 534 and 535 is the one generally in use at the Children's Hospital in Boston, and is in every way serviceable. It consists of a steel upright, which is attached below to the sole plate of the shoe. It runs up nearly to the origin of the adductor muscles, but it must fall a little short of them or

FIG. 534.—Apparatus for Bow Legs. (Children's Hospital Report.)

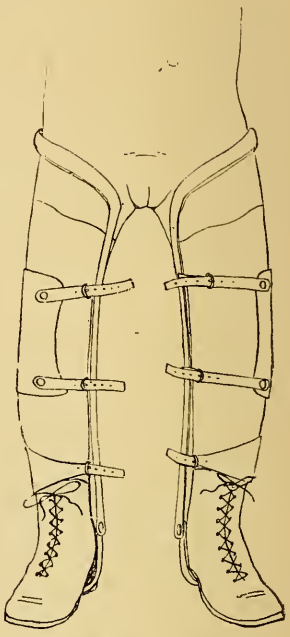

FIG. 535.—Same, Applied.

it will excoriate the skin in walking. The upright is then bent forward and upward, and curved to fit into the groin and come up as far as the posterior part of the dorsum of the ilium. In this way a lever is provided with which to evert the feet to any extent by altering the curve of these arms, and strapping them together behind. Pads for the outside of the legs are made of leather and buckled by two or three straps to the upright, opposite the greatest convexity of the curve. In severe cases it is advisable to have a flat steel pad plate covered with leather, where the upper part of the upright bears against the thigh. When the curve is wholly in the tibia and the child does not "toe in," it is sufficient to carry the upright just above the knee, and to end it there in a pad.

Anterior tibial curves are not susceptible of improvement or cure by mechanical treatment except in very slight cases in which the bones are soft and the curve is very slight. In these cases it is useful to apply to the foot a steel sole plate with a cup-shaped rim to the heel, forming its posterior border. To this two uprights are attached and an anterior pad pulls the lower part of the tibia backward, pulling from these uprights.

The mechanical treatment of bow legs should be advised in cases in which the deformity is severe or sufficiently obstinate to make it doubtful whether spontaneous outgrowth of the deformity will occur, because braces do no harm, and do not retard spontaneous improvement. After the age of three or four it is not generally worth while to begin mechanical treatment. Children who are too old for mechanical treatment can either be operated upon at once or allowed to wait as long as one wishes for operation, for in eburnated and hardened bones the deformity will not grow any worse.

In the case of babies the expectant plan of treatment is the one to be followed at first.

Mechanical treatment for bow legs is generally useless after the bones have become thoroughly ossified.

(c) *Operative Treatment of Bow Legs.*

Osteoclasis.—The manual fracture of bones is a procedure which, though an old one, is not to be recommended. Much force is required even in the case of the bones of young children, and the method also lacks precision as to the point of breaking. In the case of bones still soft, if it is desired to operate at that stage, manual fracture has a place in the operative treatment, but even then manual fracture presents no advantage over the osteoclasts.

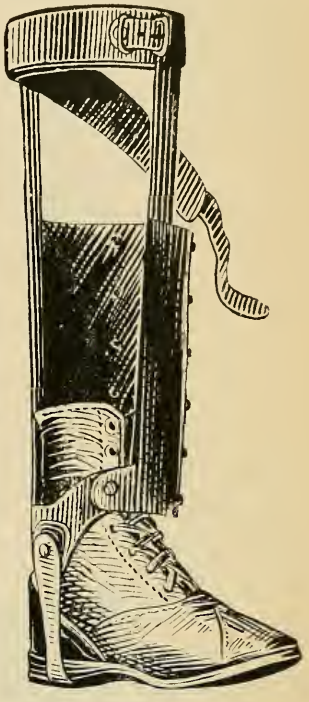

FIG. 536.—Splint for Bow Legs. (Dane.)

Mechanical fracture is made feasible by the use of osteoclasts, of which the one of Rizzoli is the most convenient. The appliance is easily understood from the accompanying illustration. The instrument is made of heavy steel, and the rings and the screw pad all slide on the bar so as to be adjustable to any length of leg. The parts of the apparatus which come in contact with the leg are padded so that the edges shall not cut.

Osteoclasis is a simple procedure. The instrument is applied to the bared limb, the rings being adjusted as far as is possible from the point at which fracture is desired. In placing the rings of the osteoclast on the limb care should be taken not to put them too near to the joints of the ankle or knee, as the epiphyses might be separated by carelessness. The screw force is to be adjusted so as to press at the point of election for fracture, which is at the point of the greatest convexity of the curve. Pressure is increased until fracture of the bones takes place. The fibula generally breaks first, the tibia shortly afterward on continuing the screw

pressure. The fracture of the bones is evidenced by a loud snap which can be heard anywhere in the room.

The bone will usually be found to bend before fracture occurs. If the instrument is well padded there will be no danger of injury of the

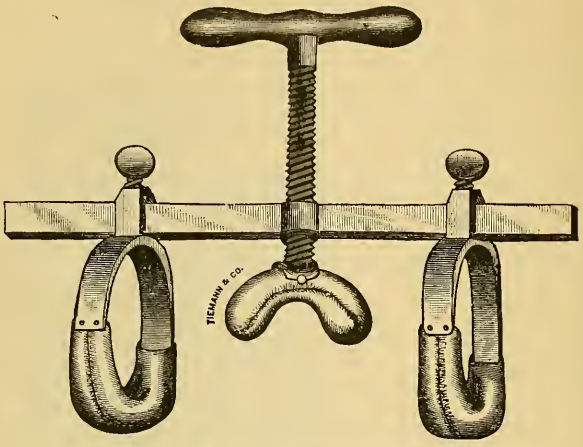

FIG. 537.—Rizzoli's Osteoclast.

skin from the temporary pressure necessary for fracture, although the amount of this pressure may be very great. The skin will become blanched or congested, but after the removal of the osteoclast the color will be found normal, with but slight evidence of pressure.

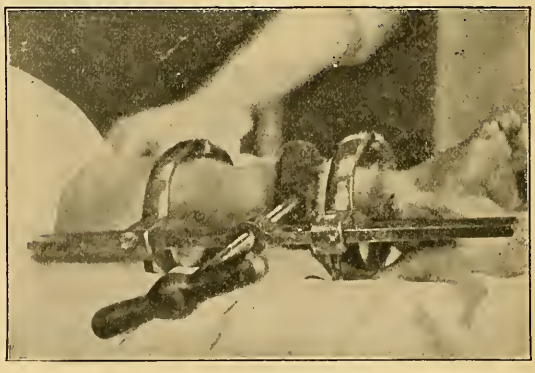

FIG. 538.—Method of applying Osteoclast.

The fracture will be found to have taken place opposite to the screw-pad plate.

After the bone has been broken, the osteoclast should be removed, the fragments placed with the hand in the desired position, without any unnecessary stirring up of the bones at the seat of fracture, sheet wad-

ding placed on the leg, and the limb fixed in a plaster bandage and held in a carefully corrected position. The bandage should reach from the toes to the hip, and the limb should be held in the corrected position until the plaster has hardened thoroughly. When there is a rotation of the tibia as well as a curvature, care should be taken to see that this also is remedied and that the limb is fixed in a normal position.

Experience has shown that the procedure is ordinarily free from risk; and in properly selected cases the danger of non-union after fracture may be disregarded. The fracture is a transverse one and there is no danger of splintering the bone. A number of experiments upon the cadaver were made by the writers with reference to this point, and it was found

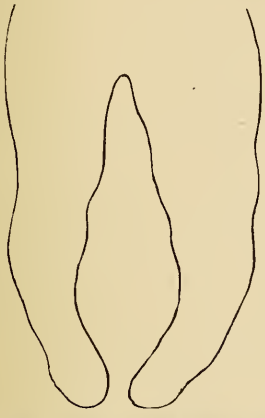

FIG. 539.—Bow Legs, curve mostly in Tibia.

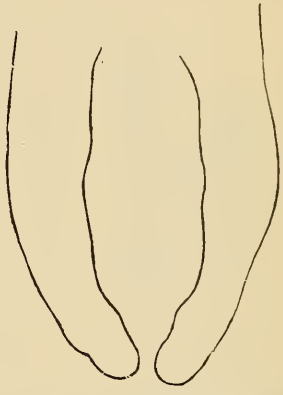

FIG. 540.—Bow Legs, gradual Curve involving the whole Leg.

that although splintering will take place in dry bone if subjected to fracture by an osteoclast, yet bone undried, as found in the dissecting-room, will break transversely; the fracture takes place as a sharp linear fracture half-way through the bone. The part of the bone nearest the side of pressure breaks with an irregular line of fracture, as if torn.

The amount of force required for the fracture of an adult bone is very great, so much so as to make osteotomy in most instances a preferable procedure.

Osteoclasis near the joints is difficult, but in the shaft of the tibia the operation is a most excellent one, yielding most satisfactory results with but little discomfort to the patient.

In the large number of cases of osteoclasis which have come in the experience of the writers at the Boston Children's Hospital they know of no cases in any way unsatisfactory in the results. Cases should not be operated upon unless the bones are fairly strong—that is, not if the rhachitic process has not been well arrested—as recurrence of the deformity may take place. This has occurred a few times in the experience of the

writers and a second operation has been necessary, but such cases are very rare, and have served only to emphasize the necessity of avoiding too early an operation.

Patients have been operated on as young as three years, but as a rule the operation should not be performed before the age of four.

The limb should remain in a fixed bandage for four or five weeks, and no appliance is needed as an after-treatment.

Anterior Bow Legs.—In the treatment of anterior bow legs the tibia may be broken by the osteoclast applied in the usual way, and after the fracture has been loosened by the hands the leg may be set straight. Tenotomy of the tendo Achillis aids this attempt and is generally necessary. Osteotomy, however, as a rule is more satisfactory in these cases.

FIG. 541.—Anterior Bow-legs.

Osteotomy should be employed in place of osteoclasis in cases of bow legs (1) when the curvature is so near the joint that osteoclasis is not practicable; (2) when the bone is so strong that osteoclasis is not feasible; (3) when several curves exist in the same leg, or when the curvature is anterior; (4) in cases of bow leg in which the distortion is largely in the lower epiphysis of the femur; (5) in cases in which it is desired to locate the fracture very accurately, as in badly united fractures of both bones of the leg with displacement.

Osteotomy for bow legs is a similar operation to that for knock-knee; the division of bone is made wherever it appears most necessary, and no formal operation can be laid down. In young children the fibula need not be cut with the osteotome but can be broken manually. Osteotomy will in general offer the best treatment for anterior bow legs. The tibia should be cut nearly through, preferably from behind at the level of the greatest angularity, and the limb fractured, and tenotomy of the tendo Achillis will generally be an aid to the rectification of the foot. It is not necessary to remove a wedge of bone except in very severe cases, simple linear osteotomy answering every purpose.

The removal of a wedge of bone shortens the leg and is to be avoided if possible. It is necessary only in very sharp curves. It is often better

to cut the posterior surface of the tibia first in doing osteotomy for anterior bow legs, as this allows the line of fracture to gape at its posterior aspect.

A practical way to determine the amount of bone to be removed is the following: an outline of the leg is taken by means of a tracing drawn on paper and then cut out. If a wedge-shaped section of this profile of the leg be made and enough removed so that the pattern of the leg be straight, the paper wedge will indicate the amount of bone which needs removal.

After osteotomy it is not necessary to wire the fragments of bone to-

FIG. 542.—Slight Grade of Knock-knee seen after Osteotomy for Bow Legs.

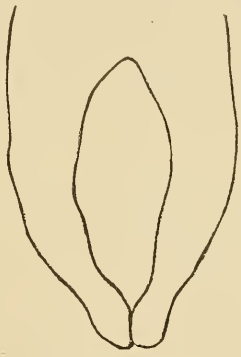

FIG. 543.—Composite of Ten Cases of Bow Legs before Operation. (Goldthwait.)

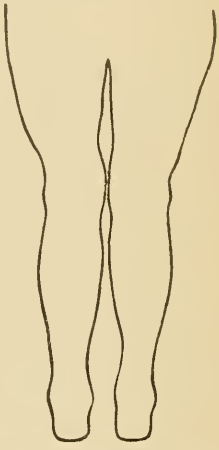

FIG. 544.—Composite Tracing of all Twenty-eight Cases (except the Case of Relapse above mentioned).

gether; if they are placed in apposition and fixed, union can be expected to take place.

A free skin incision is of course necessary for the removal of a wedge of bone from the tibia, and the periosteum should be incised and scraped away from the proposed seat of operation with very great care, and after the removal of the wedge it should be stitched carefully together. In simple linear osteotomy no skin incision is necessary.

Ultimate Results of Osteotomy and Osteoclasis.—J. E. Goldthwait traced out twenty-eight cases of knock-knee and bow legs operated on in the Children's Hospital, not taking into account any case operated within a year and a half of the beginning of his investigation. There were eleven cases of Macewen's osteotomy for knock-knee and eleven of osteoclasis for bow legs, while there were five cases of anterior bowing of the tibia treated by osteotomy. The average length of time after the opera-

tion was four years, and of these cases only one had relapsed. That was a colored boy four and one-half years old who presented a condition of extreme rickets. He had both knock-knee and bow legs, and osteoclasis and osteotomy were done and the knock-knee had recurred somewhat since operation.

The figures (543 and 544), which are taken from composite tracings of each group of cases, show the condition of these patients before and after operation.

The figure showing the combined results in knock-knees and bow legs might be liable to misinterpretation, inasmuch as the deformities would counteract each other, but the legs of all these children were perfectly straight.

The average age at the time of operation was four years. The youngest child was two years old and the eldest ten.

Non-Union of the Bones.—Non-union of the bones is very rare after either osteotomy or osteoclasis. Such cases, however, occasionally occur, as in a case reported by Marsh to the Midland Medical Society, in which non-union of the tibia was present. In this case this seemed to be attributable to local causes.

Osteoclasis is preferable when it is possible, as being theoretically the safer operation, though practically statistics show such excellent results in osteotomy that a choice of methods becomes one of the personal preference of the surgeon.

CHAPTER XIX.

TORTICOLLIS.

Definition. — Etiology. — Pathological anatomy. — Symptoms. — Diagnosis. — Prognosis. — Treatment. — Mechanical. — Operative. — Congenital elevation of the shoulder.

Definition.

The name torticollis is given to that distortion of the head which causes it to be held awry, and this condition is either constant or intermittent.

The other names by which this affection is known are wry-neck, caput obstipum, collum distortum, cou tortu, Schiefhals.

Etiology.

Torticollis may be congenital or acquired. In 264 cases Whitman[1] classed 32 as congenital; in 70 cases analyzed by Redard[2] 18 were considered congenital.

(1) *Congenital Torticollis.*—(*a*) It may exist in connection with other deformities, such as club-foot and similar malformations. In these cases it seems proper to attribute its existence to those intra-uterine conditions causing other deformities.

(*b*) Abnormal pressure of the uterus seems to be accountable for another class of cases in which the cranium and face on the affected side are smaller at birth.

(*c*) Amniotic adhesions as a cause are spoken of by Petersen.

(*d*) Inflammation of the muscles seems to be proved by the pathological findings in certain cases and must be mentioned as an occasional cause.

(*e*) Arrest of the development of the muscles due to an affection of the nerves or nerve centres must be spoken of as a cause often advanced to account for torticollis.[3]

(*f*) Rupture of the sterno-mastoid muscle occurring at birth has been

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[1] Trans. Am. Orth. Assn., iv., p. 293.

[2] "Le Torticollis," etc., Paris, 1898 (full bibliography).

[3] Osler: N. Y. Med. Journ., December 12th, 1891; Golding Bird: Guy's Hosp. Rep., 1890; Shaffer: Trans. Am. Orth. Assn., vol. iv., p. 305.

much discussed [1] as a cause of torticollis. Although for many reasons its consideration would seem to come rather under the acquired than the congenital class, it has seemed best to consider it here, since in many instances it is probably the result of congenitally shortened or diseased muscles and because it exists from birth when present.

In the majority of cases of congenital torticollis a difficult labor has occurred (Redard).

Experiments on rabbits by Witzel, in which hæmatoma of the sterno-mastoid muscle was caused experimentally, were not followed by torticollis.[2] Similar experiments by Fabry,[3] Mikulicz,[4] and Kader were without positive results.

There is no question that rupture of the muscle occurs at times during labor,[5] and hæmatoma of the sterno-mastoid muscle is not an excessively rare condition. Pincus and Kader report series of cases of hæmatoma. Whitman was able to report on the later condition of five children among nineteen cases of hæmatoma of this muscle seen at the Hospital for the Ruptured and Crippled. Among these there was no torticollis. Quisling[6] reached a similar result in a similar series of cases. Redard in twelve cases observed for two years found no torticollis resulting. Brooks,[7] Smith,[8] and Jacobi have reported the disappearance of such tumors without resulting deformity. It has been demonstrated experimentally that contusions of muscles are not followed by shortening of the muscle. A case was seen by one of the writers shortly after birth with a hæmatoma of the sterno-mastoid muscle but no marked torticollis, and two years later appeared with a typical torticollis.[9]

It must be remembered that if a shortened muscle existed during intra-uterine life it might easily be ruptured during birth [10] and form a hæmatoma. It may, then, be said that hæmatoma of the sterno-mastoid muscle in most instances is not followed by torticollis.

(*g*) Imperfections in the atlas and cervical vertebræ have in some reported cases been the cause of congenital torticollis (Uhde, Rex).

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[1] Jeannel: "Encyc. Int. de Chir.," 1886, v., 777; Busch: Berl. klin. Woch., 1873, xxxvii.; Stromeyer: "Handbch. der Chir.," ii., 4; Fischer: Deutsch. Chir., 1880, Lief. 43; Volkmann: Cent. f. Chir., 1885, xiv., 233.

[2] Witzel: Deutsch. Zeit. f. Chir., 1883, xviii., 534; Petersen: Zeitsch. f. Orth. Chir., i., L. 1, 113.

[3] Fabry: Inaug. Diss., Bonn, 1885.

[4] Cent. f. Chir., 1895, No. 1.

[5] Deutsches Arch. f. Chir., 1882, p. 181; Cent. für. Gyn., 1886, No. 9; Bouchut: "Traité Prat. de Mal. des Nouv. Nées," Paris, 1750.

[6] Archiv f. Kinderheilkunde, 1891, Bd. xii., 5 and 6.

[7] N. Y. Med. Rec., Februarv 27th, 1886.

[8] Petersen: Cent. f. Gyn., 1896, No. 48.

[9] R. W. Lovett: Boston Med. and Surg. Journal, 1892.

[10] Reneke: Cent. f. Gyn., 1886, xxii.

(2) *Acquired Torticollis.*—The etiology of this form of the affection is a somewhat difficult matter to present on account of the manifold conditions which may cause an abnormal position of the head either temporary or permanent.

There are several well-recognized types which may be considered first.

(*a*) Cicatricial contraction of the skin or deeper tissues following burns, ulcerations, and similar conditions may cause torticollis.

(*b*) Traumatism to the neck and head is at times followed by torticollis, sometimes apparently due to direct injury to the muscles of one side and sometimes to a synovitis of the intervertebral joints.

(*c*) Dislocation of the upper cervical vertebræ is usually accompanied by torticollis.

(*d*) Inflammation of the muscle. Rheumatism may cause inflammation of the sterno-mastoid or other neck muscles and a resulting torticollis. A myositis of the sterno-mastoid muscle may occur in the acute infectious diseases, such as typhus, meningitis, scarlet fever, diphtheria, etc., and cause torticollis. A similar result may occur from a chronic myositis, possibly ossifying or due to syphilis.

(*e*) A form of torticollis, wholly reflex in character, or partly reflex and partly mechanical may occur in inflammation of the cervical lymph nodes or with deep cervical abscesses, retropharyngeal abscesses, inflammations of the ear, parotitis, adenoid vegetations in the nasopharynx, tumors of the neck, and cerebral lesions. Whitman estimated that cervical adenitis was the cause of fifty per cent of one hundred and six cases of acquired torticollis analyzed by him.[1] Neuralgia of the spinal accessory or cervico-brachial nerves may be accompanied by torticollis.[2]

(*f*) Ocular torticollis may occur when a difference in the plane of vision of the eyes exists or when a difference in power of the two eyes is present.[3]

(*g*) Compensatory torticollis may occur as secondary to lateral curvature and similar deformities.

(*h*) Physiological torticollis, in some cases severe enough to require operation,[4] has been described in which the voluntary habit of holding the head to one side has become a permanent deformity.

(*i*) It may result from certain occupations in which the overuse of one sterno-mastoid muscle is necessary, as in the case of a factory girl who was continually compelled by her work to turn the head to one side, or in the case of a person carrying heavy loads continually on one shoulder.

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[1] Whitman: Orth. Trans., vol. iv., p. 293.

[2] Dollinger: Pester Med. Chir. Presse, 1889, No. 48.

[3] Bradford: Trans. Am. Orth. Assn., 1889, vol. i., p. 46; Lovett: Trans. Am. Orth. Assn., 1889, vol. i.

[4] Mellet: "Manuel Prat. d'Orth.," Paris, 1844.

(*j*) Rickets has been demonstrated as the cause of some cases (Phocas).

(*k*) Pott's disease of the cervical vertebræ has been already mentioned as a frequent cause of what is generally classed as false torticollis.

(*l*) Injury to the nerve centres at the time of birth may apparently

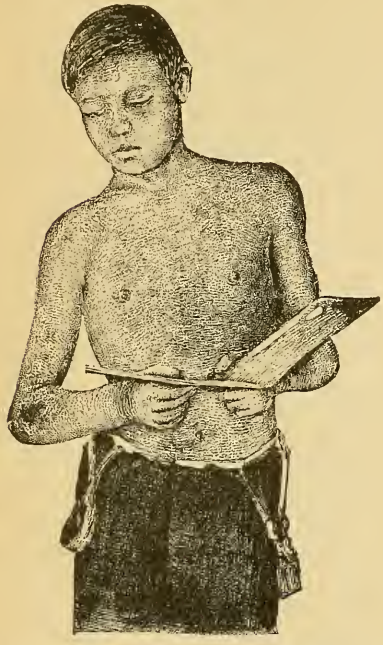

FIG. 545.—Ocular Torticollis. Habitual position of head.

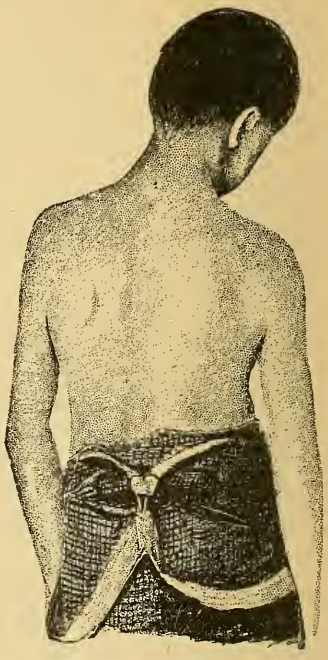

FIG. 546.—Ocular Torticollis; Back View. Habitual position.

cause torticollis, as in a case observed by the writers in which torticollis was attributable to a depressed fracture of the skull caused by the use of forceps.

(*m*) *Spastic Torticollis.*—In this class are included those cases which arise from nerve irritation. This may be central, situated along the course of the spinal accessory nerve, or may be the local manifestation of a more general nervous irritation as in spinal irritation. In some cases of the spasmodic form, the affection is closely allied to writers' cramp, spasmodic tic of the face, etc., and in one case observed there was a nodding motion to the head.

The spasm in this class of cases can be either tonic or clonic.

Frequently no definite cause can be found to explain the occurrence of the affection, but it is evidently the result of general malnutrition or general nervous disturbance having this as a local manifestation. Not infrequently in these cases there will be found a definite exciting cause,

such as fright, grief, etc. In this class might be included the "torticollis mental" of Brissaud[1] and Bompaire.[2]

Many of the above causes seem each to be but one out of many factors. In a large percentage of cases there will be found to be a neurotic family or personal history, also the general condition seems to have a very considerable influence; many cases occur after severe overwork, in this particular bearing a close analogy to professional cramp or spasm.

(*n*) *Paralytic torticollis* may rarely occur as the result of paralysis of the spinal accessory nerve from such causes as rheumatism or trauma. It may also result from anterior poliomyelitis[3] or progressive muscular atrophy.[4]

Pathology.

The pathological condition existing in congenital torticollis has been demonstrated by autopsy and by pieces of muscle removed at operation. In some instances the contracted muscle appears normal, but more often the muscular substance is replaced by fibrous tissue. This may occur in small patches[5] or the whole muscle may be transformed into a tendinous band. In the majority of cases of fibrous degeneration of the muscle it is adherent to the sheath, and in some instances muscle and sheath are fused in one fibrous band.

The sternal part of the muscle is more often involved than the clavicular. The changes described are to be classed as fibrous myositis, the reason for which has not yet been formulated. Other muscles besides the sterno-mastoid may be degenerated, and all of the structures on that side of the neck are of course shortened. Changes to be classed as perimyositis have been demonstrated in certain cases.[6]

Shortening of the muscle on the affected side may amount to several centimetres. In a case measured by Shaffer when the patient was six years old and again when sixteen, the length of the muscle was found to be the same at both times.[7]

Secondary changes occur in long-continued torticollis. The most marked is asymmetry of the face; a deviation of the line of the nose from a right angle to the line of the eyes, is noticed; furthermore, the distances from the outer point of the two eyes to the outer corners of the mouth are not the same, while the cheek on the contracted side is less prominent and the features on the affected side of the face are smaller

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[1] Union Médicale, 1894, p. 161.

[2] "Torticollis Mentale." Thèse de Paris, 1894.

[3] Hoffa: "Orth. Chirurgie," 1898, p. 188.

[4] Dejerine and Flandre, quoted by Redard: "Le Torticollis," etc., 1898, p. 40.

[5] Volkmann: Cent. f. Chir., 1885, No. 14; Vallert: *Ibid.*, 1890, No. 38.

[6] Archiv. d. Pédiatrie, 1890, No. 1.

[7] Orth. Trans., iv., p. 305.

than those upon the other side. This asymmetry diminishes if the deformity is corrected early.

Asymmetry of the skull may also be found, as well as a diminished size of the cerebral hemisphere[1] on the affected side. The carotid artery of the affected side has been in certain cases found smaller.[2]

This asymmetry of the face may occur in acquired torticollis, and it may be present at birth in congenital cases.[3] It may, on the other hand, be present at birth without the existence of torticollis.

Asymmetry of the face in torticollis has been attributed to many causes. The ones most deserving of mention are as follows: that it is due to muscular tension;[4] to a difference in blood supply on the two sides;[5] to interference with the function of one side; to respiratory difficulty due to the insufficiency of the muscles on one side.[6]

Lateral curvature of the spine may result from long-continued torticollis, and a difference in the length of the clavicles has been noted.

In spasmodic torticollis gross organic lesions are not, as a rule, to be found.

Symptoms.

Torticollis is either acute or chronic. In the acute form the history is that of an acute muscular rheumatism with some constitutional disturbance and sudden onset with a great deal of pain on movement of the head, and the head is held to one side. The acute stage, however, lasts but a short time, and in general it may be said that pain in wry-neck is not a permanent symptom. The chief discomfort from wry-neck is the disfigurement which is always noticeable and never to be concealed. There may be pain in the neighborhood of the affected muscles and their insertions. Palpation usually discloses considerable tenderness. The position assumed by the head is more or less typical and is described farther on.

The chronic form may develop from the acute form. It may be, as has been said, a congenital distortion, or it may be of gradual development from any of the causes mentioned above or from no known cause.

The position held by the head varies necessarily with the muscles affected. When the sterno-cleido-mastoid is attacked, the ear of the

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[1] Greffie: Montpellier Méd., November 16th, 1890; Broca: Bull. Méd., 1894, No. 42, p. 493.

[2] Witzel: Loc. cit.

[3] Osler: N. Y. Med. Journ., December 12th, 1891; Golding Bird: Guy's Hosp. Rep., xlvii., 1890; Krummacher: Cent. f. Chir., 1889, No. xii.; Beely: Zeitsch. f. orth. Chir., Bd. ii.; Meinhard Schmidt: Cent. f. Chir., July 26th, 1890.

[4] Falkenburg: Deutsch. Zeit. f. Chir. 1885, xix., 338.

[5] Bouvier: "Loc. Clin. sur les Mal.," etc., Paris, 1858.

[6] Stromeyer: "Handbch. der Chir.," ii., p. 4, 1864.

affected side is brought near to the sternum and the face slightly rotated to the opposite side. If the trapezius or posterior muscles are also affected, the head will also be drawn back, the chin elevated above its normal level, and the features on the side of the spasm drawn below those on the opposite side. In severe and especially in persistent cases the jaw is rotated so that the teeth cannot be approximated. In proportion to the extent the trapezius is involved the head is drawn toward the shoulder, while in proportion to the extent in which the spasm involves the sterno-mastoid alone, rotation and elevation of the chin predominate. In addition to these muscles the platysma, the scaleni, splenii, and other deep muscles of the neck are sometimes affected and modify more or less the position of the head. The attitude is sometimes so peculiar as to render it difficult to determine exactly what muscles are affected. On palpation certain muscles will be found to be hard to the touch and others flaccid; no pain is felt, but any attempt to rectify the head may cause pain if persisted in. Rotation of the head is free up to a certain limit, varying in extent. It is not possible to move the head in a direction against the spasm, and a persistent effort may cause considerable pain.

But in old torticollis pain is absent and only the tough contraction restricts the mobility. In the opposite direction, motion is greatly limited, and is often possible only by slow and careful manipulation. As a rule, in the chronic affection, pain and tenderness are absent.

A deviation of the spinal column and a lateral curvature with rotation necessarily follow torticollis and may materially add to the patient's discomfort. In order to retain the head in a vertical position, the patient, unable to twist the cervical spinal column, will twist the trunk, leaving one shoulder leaning to the side. This is accompanied by rotation of the vertebræ and projection of the ribs backward on the convexity of the lateral curve, precisely as is seen in the compensating curves of any marked lateral curvature. Although the head is twisted, strabismus rarely exists except in cases of true ocular torticollis already mentioned. Although the movement of the larynx in extreme cases is apparently limited by the distortion, speech is not affected, though the voice in singing may become modified by the development of this distortion.

The intermittent form of torticollis is much less common. In the cases observed by the writers it was due to the disturbance of the nervous system from overwork, and to anxiety. At times the head could be held in a proper position, but locomotion or any excitement or the apprehension of being observed would produce such a contraction of the head that it would be twisted violently to one side and rotated to an extreme limit. A slight pressure of the hand steadying the head would ordinarily correct it, but when the muscular contraction became excited, great force was required to hold the head in place. In a recumbent position, the contraction did not ordinarily take place. It usually disappears during

sleep. The spasm is sometimes tonic and sometimes clonic, and sometimes pain is excited by the muscular contraction. It is usually confined to the muscles of one side (tic giratoire). In one instance reported by Studel, the muscular cramp alternated between the muscles of the left side and those of the right, constituting a veritable chorea.

Slight twitchings of the muscles are sometimes observed for some time previous to an outbreak of the spasmodic condition.

Diagnosis.

There is no difficulty in recognizing the deformity called wry-neck. The head is twisted to one side, the chin being to the right or left of the sterno-clavicular notch, while the face is turned to one side and partly upward. The shoulders are held obliquely to the trunk, twisted, in order to bring the face so far as possible in a vertical line. Certain of the muscles, frequently the sterno-cleido-mastoid, are felt hard on palpation; some rotation of the head is possible, but perfect free rotation of the head is checked by the contracted muscles.

A diagnosis of the cause and situation of wry-neck is more difficult, as well as an attempt to distinguish it from other affections which give rise to this malformation, a matter which is of great importance. Such are disease of the cervical vertebra, enlarged cervical glands, cervical abscess, and stiff neck from ordinary cold.

The diagnosis between anterior and posterior torticollis (or torticollis due to contraction of the anterior muscles, chiefly the sterno-cleido-mastoid, and that due to the contraction of the posterior muscles, the trapezius and splenius capitis, etc.) is to be based on palpation chiefly.

Palpation also, with a clinical history of paralysis and the evidence of paralysis elsewhere, is sufficient usually to determine the diagnosis of paralytic torticollis.

Torticollis dependent upon enlarged and inflamed glands can usually be recognized by the evidence of glandular enlargement.

There is ordinarily little difficulty in recognizing the common acute wry-neck. Its course is acute, the deformity appears suddenly, and it is usually accompanied by pain. Improvement is to be noticed in a comparatively short time.

For the diagnosis of real torticollis from that due to Pott's disease the reader is referred to the chapter on Pott's disease, but in general it may be said that in the latter there is greater rigidity, and this involves all the muscles of the neck, and particularly the posterior groups. The pain elicited by attempts to twist the head is greater. When a patient with cervical caries attempts to lie down or turn over the head is instinctively steadied with the hand, while in true torticollis this is not so constant a symptom.

There is rarely any difficulty in distinguishing anterior torticollis from wry-neck due to caries of the spine, as in the latter one sterno-mastoid muscle is not prominently contracted, but it is sometimes impossible to determine without several examinations and a continued observation of the case whether posterior torticollis is secondary to a caries or is idiopathic. It may be said that in all cases of posterior torticollis Pott's disease must be suspected, and the symptoms of cervical caries—referred pain, projection of the vertebra, stiffness of the back—must be carefully and positively excluded before a diagnosis of posterior torticollis can be formed.

Prognosis.

The acute idiopathic wry-neck due to muscular inflammation runs a short course and tends naturally to recovery, though in a few cases it may become chronic. Torticollis due to abscess of the cervical glands terminates with the complete discharge of the abscess as a rule. Intermittent spasmodic torticollis may become cured spontaneously, or may, as is more common, remain without change for many years. Congenital forms of torticollis and the common acquired form (associated with muscular contraction which has become chronic and developed fibrous muscular degeneration) are of course incurable without surgical interference. Little or no constitutional disturbance follows this affection, which is more distressing on account of the unsightliness than from any actual discomfort.

The deformity is one which is eminently curable by surgical intervention. Complete correction and permanent cure are possible in all cases except in the intermittent form, which is dependent upon a general depressed state of the nervous system, in which a cure cannot always be promised.

Treatment.

The treatment of torticollis depends to a great extent on the variety. In acute torticollis due to the inflammation of the muscles, the treatment is largely the alleviation of the symptoms. This is best done by the application of moist heat in the forms of cataplasms and poultices, the inunction of oleate of atropine or morphine to relieve the pain, or the subcutaneous injections of morphine. Rest of the head and anti-febrile constitutional treatment are of course advisable when there is any fever.

Torticollis due to cervical Pott's disease is treated according to the principles of treatment of that affection, and will disappear with the improvement of the bone disease. Torticollis due to muscular contraction secondary to cervical abscesses or enlarged glands is corrected by the proper treatment of cervical abscess. Torticollis due to an affection of the eye is to be corrected by proper ocular treatment.

The treatment of wry-neck due to permanent muscular contraction is either operative, or purely mechanical, or mechanical and operative.

Mechanical Treatment.—Mechanical treatment without the aid of operation is usually unsuccessful, except in the lightest cases.

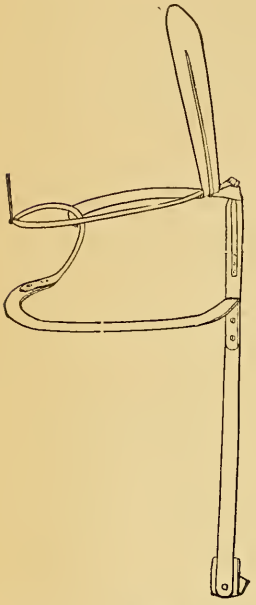

FIG. 547.—Buckminster Brown's Wire Collar for Holding Head.

Massage and passive manipulation are of value in mild cases in connection with mechanical treatment.

The simplest of all forms of appliance is that invented by Buckminster Brown, of Boston. A wire collar passes around the neck and is furnished with a plate under the chin, arranged so as to press on the deflected side of the chin. Pressure is also arranged to be applied to the inclined side of the head behind the ear. The wire collar is attached to a ring which rests upon the shoulder, and in the back this is furnished with an arm which passes down the back. Straps are fastened to this, one passes around the trunk, and another around the shoulder on the side of the deflected chin; by tightening this latter strap it will be found that pressure is exerted on the chin in the proper direction.

Mechanical treatment is of value chiefly in retaining the correction obtained by operative measures.

Operative Treatment.—The operative procedures are tenotomy and open incision.

Tenotomy is applicable to contraction of the sterno-cleido-mastoid muscle. The place of election for division of the sterno-mastoid is in its lower part. In its upper part it is more or less surrounded with nerve filaments. A strong tenotome is selected, the skin is pulled down and the tenotome is inserted through the skin and over the clavicle. The skin is then allowed to slip up and the tenotome, which has been inserted in the skin, moves with it and should lie half an inch to an inch above the clavicle. Care should have been taken to avoid the external jugular vein which is readily seen or made apparent by pressure and distention of the vein. The blade of the tenotome is then passed underneath the contracting muscle and its sheath, its cutting edge is then turned toward the skin and by a careful sawing motion the tendon is felt to give way; it being essential that all of the contracting tissue be divided and that the muscle be not simply transfixed. After this the head should be fixed in the corrected position.

The head should be immediately rectified and retained in a corrected

position, either by means of a plaster-of-Paris bandage enclosing the head and trunk, or by placing the patient in bed secured to the bed frame described in the treatment of caries of the spine, and applying straps, sticking-plaster, and weights in the manner shown in the accompanying

FIG. 548.

FIG. 549.

FIGS. 548 and 549.—Retention Appliance for Torticollis. (Children's Hospital Report.)

illustration. This can be employed for a week or ten days and a light retention appliance be used, that of Buckminster Brown being found simple and convenient.

Open Incision.—It will be found practically impossible in most cases to divide entirely with the tenotome all the deeper contracted fibres, and much will have to be left to mechanical stretching. For this reason an open incision is more thorough and preferable to tenotomy as offering the best means of correction. The writers have entirely abandoned subcutaneous tenotomy in the treatment of wry-neck in favor of open incision.

An incision parallel to the clavicle and an inch above it should be made reaching across the contracting muscle, a director should be passed

under the muscles and fascia, and the whole divided with care. After this is done, the skin should be sewn up and the head fixed. The head should be kept in an over-corrected position until union of the divided structures has taken place. In ten days or a fortnight the Buckminster Brown head support can be applied.

This latter should be worn for from three to six months, when permanent cure should be established. Without the use of apparatus after operation relapse is likely to occur.

Both in tenotomy and in open incision there is danger of wounding the internal jugular vein; deaths from this cause have been reported after tenotomy. The writers would record one case in their experience in which the internal jugular was wounded in an open incision. It was tied and no

FIG. 550.—Side Traction for Twisting the Head in Torticollis after Operation. (Children's Hospital Report.)

untoward results followed, the patient making a perfect recovery. The vein lies under the deep fascia, and can be avoided in open incision if the neck be not stretched and care be taken not to open the deep cervical fascia.

The results of the correction of torticollis by open division are extremely satisfactory. The asymmetry of the face becomes more noticeable after correction than it was in the deformed position, but disappears gradually if the corrected position is retained.

Beside the deformity largely associated with contraction of the sternomastoid muscle—anterior torticollis—another form is seen, as has been already mentioned, viz., posterior torticollis. This variety constitutes a class of obstinate cases. The only efficacious treatment is that of forcible correction without tenotomy, for the reason that, as a rule, the muscles are too deep or extensive to be tenotomized. The writers have divided the outer bands of the anterior scalenus and trapezius by open incision and can report the feasibility of the procedure. In correcting this de-

formity the patient should be thoroughly anæsthetized, and an assistant should hold the shoulders firmly, while the patient should be so placed that the head projects beyond the end of the operating-table. The head should be held by the hands of the surgeon and rotated in all directions, considerable force being used. The danger of fracturing the spine is in such cases of course so slight as to be disregarded, and the deformity can be over-corrected. After the operation the head should be fixed in some retaining appliance.

The use of correcting appliances will be required several months after operation to enable the soft parts to adapt themselves to the normal

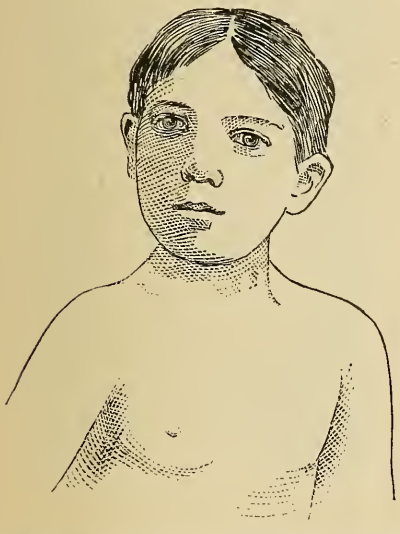

FIG. 551.—Result of Open Incision and Correction in a Girl of Eight, One Month after Operation.

FIG. 552.—Result of Open Incision One Year after Operation in a Girl of Sixteen. Shows also the unequal development of the face.

position. When the patient is under an anæsthetic, complete correction or over-correction during the operation is a method which saves the patient suffering and gives the best results. The selection of the form of retention appliance will depend upon circumstances; fixed plaster-of-Paris bandages, removable stiffened leather collars, moulded upon a cast, or the light steel appliance already described will be found efficacious, the last being the least unsightly and uncomfortable to the patient.

The treatment of torticollis may be summarized as follows: Anterior variety: division by open incision of such muscular bands or fibres as are within the reach of the knife. Posterior variety: manual correction and over-correction of the deformity under an anæsthetic; fixation

of the head in an over-corrected position and the subsequent wearing of retention appliances. It may be added that the result of thorough treatment is most satisfactory.

Spastic Torticollis.—The treatment of spastic torticollis is mechanical and constitutional. These cases are often largely due to a depressed nervous condition—a condition requiring for a cure an improvement in the patient's nervous condition.

Fixation, however, is sometimes of benefit; one cure is reported[1] by the use of a plaster helmet. Hall[2] reported two cures from the wearing of a spring clamp on the back of the neck. The apparatus consisted of a

FIG. 553.—Posterior Torticollis before Forcible Straightening.

FIG. 554.—After Operation.

light circular steel spring like the ordinary trousers clamp for the use of bicyclists. This reached as far forward as the anterior border of the sterno-mastoid muscles and had a vertical attachment of steel, running down the back for six inches in the median line, which went under the collar. The horizontal piece was most efficient when at the level of the jaw. Lund[3] recorded a cure from the use of an apparatus which held the head fixed in a somewhat extended position. This consisted of an upright running the length of the spine, terminating above in two lateral pads steadying and fixing the occiput by means of a strap passing around the forehead. Such treatment is, however, generally unsatisfactory.

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[1] Quoted by Hall.

[2] H. J. Hall: Orth. Trans., vol. xi., p. 233.

[3] Boston Med. and Surg. Journ., March 9th, 1899, p. 236.

Constitutional treatment in the way of change of scenery and air, and rest from occupation are of great help. In some instances of clonic torticollis there is a spontaneous cure; but with these exceptions torticollis is an affection which becomes persistent, and unless corrected becomes a permanent deformity.

Massage and galvanism to the affected muscles are apparently of benefit in a certain number of cases. These are almost without exception of the clonic form and in patients whose system has been overtaxed, and attention to the health is of fully as great importance. Systematic muscular exercises and development of muscular control by muscle training have been beneficial.

When conservative measures have been unsuccessful recourse can be had to operative methods. These have been successful in a number of instances in the hands of Kocher, Keen, and Richardson.

Nerve-stretching of the branch of the spinal accessory supplying the sterno-mastoid as well as division of the nerve has been of temporary benefit, but is usually followed by a relapse. And as other muscles besides the sterno-mastoid are involved in the causation of this deformity, Keen has recommended and practised a division of the roots of the posterior cervical nerves in addition to the division of the branch of the spinal accessory. Relapse, however, may follow these measures in certain instances, although in some cases an ultimate cure results.

The operation requires careful dissection from an incision parallel and to the outside of the sterno-mastoid in front, and behind parallel with, but a few inches to the outside of, the cervical spine. It is necessary in the latter incision to pass through the trapezius. These operative measures are to be performed usually in two sittings, and are to be followed by fixation and later by measures to improve the muscular tone, by massage, and by applying electricity to the weakened muscles. In some instances myotomy of the spastic muscles has been reported to be followed by success. In some instances in which failure has apparently followed operative interference, a permanent subsequent cure resulted after several months' treatment by massage—previously unsuccessful, as if the division of the nerve, fascia, or muscle was essential to the cure.

Congenital Elevation of the Scapula.

This condition, known also as "Sprengel's deformity" and "angeborener Hochstand der Scapula," is a somewhat unusual congenital affection in which one scapula is raised in relation to the thorax and to the clavicle of the same side as well as to the opposite scapula. The scapula is usually not only raised but so rotated that its lower angle approaches the spine. This rotation may be absent. There is usually some limitation of motion of the scapula and a resulting inability to

raise the arm to the normal extent; in most of the cases this is associated with scoliosis of a varying degree. The only theory to account for the origin of the affection is that of Sprengel, that the arm has lain behind the back in utero, a position recurring in some of these cases after birth and a position which would certainly tend to produce the position of the scapula actually found.

FIG. 555.—Congenital Elevation of the Scapula.

There is a question as to the existence of the exostosis described by some authors as being present. The scapula itself and its muscles are approximately normal in most cases. Kölliker describes a type of affection in which the deformity is actually dependent upon bony change, which is a bending forward of the body and neck of the scapula with tilting and raising as well. This type he believes to be rhachitic.

The affection in general is serious only as an asymmetrical deformity and the limitation of the use of the arm is not great.

Various operations[1] for the relief of the affection have been performed. Pitsch and Kölliker removed the upper inner angle of the scapula with marked improvement. Bolten and Eulenburg have described cases in which division of the trapezius, etc., was of benefit. The cutting of this contracted muscle was combined with massage, etc. In a case operated on by one of the writers, extensive division of the contracted muscle was followed by slight improvement, but much difficulty was experienced in holding the scapula in the corrected position.

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[1] Sprengel: Arch. f. klin. Chir., xlii., 545; Sainton: Rev. d'Orthopédie, 1898, ix., 467; Bolten: Münch. med. Woch., 1892, xxxix., 671; Pitsch: Zeitschr. f. orth. Chir., 1898, vi., p. 52; Kölliker: Centralbl. f. Chir., xx., 643; Arch. f. klin. Chir., 1898, lvii., 778; Eulenburg: 37te Versamml. Deutscher Naturf. u. Aerzte (ref. Pitsch).

CHAPTER XX.

UNILATERAL ATROPHY AND HYPERTROPHY.

Etiology and Occurrence.

Cases of unilateral difference in the growth of the body have recently attracted considerable attention chiefly because of their obscure etiology.

Hunt,[1] of Philadelphia, in 1879, made observations which led him to state that bilateral symmetry as to the length of the lower limbs was exceptional. Since then several observers have corroborated the views of Hunt. Dr. Cox[2] measured the lower limbs in fifty-four healthy persons, and in only six were the limbs of the same length. There was no uniformity with regard to which side was the longer. The variation in length was from one-eighth to seven-eighths of an inch. Wight[3] gives the measurements of sixty persons, and concludes "that the greater number of limbs, comparing the limbs of the same person, show a difference in length. About one person in every five has limbs of the same length." The difference is usually from one-eighth of an inch to an inch. In one case the difference was as great as one and three-eighths inches.

Callender[4] measured forty individuals, and found the limbs of equal length in all but two, in whom the variation was slight. He used a simple tape—all the persons measured happened to be Englishmen. Roberts[5] and Dwight[6] have attempted to settle the question by observation on the bones of skeletons. Roberts found asymmetry the rule in femora and tibiæ in eight skeletons. Dwight reported measurements in eleven skeletons; in five the femora were equal; in one case the difference was three-quarters of an inch. Tibiæ were equal in only two cases. In some cases the longer femora and tibiæ were on the same side, and in some cases on different sides.

Dr. J. Garson,[7] of London, published the results of the measurements of seventy skeletons. The lower limbs were equal, he says, in only ten per cent.

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[1] Am. Journal Med. Sciences, January, 1879.

[2] Am. Journal Med. Sciences, April, 1875.

[3] Archives Clin. Surg., vol. i., No. 8, February, 1877.

[4] St. Bartholomew's Hospital Reports, vol. xiv., 1878, p. 187.

[5] Philadelphia Med. Times, August 3d, 1878.

[6] Mass. Med. Soc. Communications, 1878, p. 175.

[7] Journal of Anat. and Phys., vol. xiii., p. 502, 1879; Nature, January 26th, 1884.

Morton[1] has made many measurements and found that among 513 boys 292 presented inequality in the length of the lower limbs varying from one-eighth of an inch to one inch and five-eighths. In 241 there was no appreciable difference in length. In none of these cases had there been previous fracture or any bone or joint disease which might have accounted for the defect. Three of the boys, including those that exhibited the greatest shortening, were aware of the fact that one limb was deficient in length. Burrell[2] reported three cases of marked unilateral atrophy only noticed when the children began to walk, when it became manifest by a limp.

Broca[3] relates the case of a boy of eleven who appeared "as if the two halves of the body were different-sized persons joined together."

Paget[4] found that there is often a difference of volume as marked as is the difference in length, and it is often difficult to say which of the two unequal limbs is the better or the more appropriate to the other parts of the body. In Hartwig's studies of the upper extremity the bones of the right arm were found to be the longest, corresponding with Hyrtl's results. Poncet[5] reported a case of alternate inequality, the right arm and the left leg being better developed.

The conclusions reached by all have been nearly identical, namely, that throughout the long bones of both extremities there exists often a certain amount of asymmetry in regard to length.

The very important theoretical and practical bearing of this is easily seen. The relation that short limbs may bear to cases of lateral curvature[6] has been discussed.

The progressive facial hemiatrophy is of interest from an etiological standpoint.

The etiology of these different forms of atrophy or hypertrophy is obscure. In the cases of injury to the joints Nicoladoni suggested a premature synostosis of the epiphyseal cartilages. The facial hemiatrophy is thought to be a trophic neurosis of certain nerve ganglia or nerves—or a simple vascular disturbance of the part has been suggested as a possible cause.

It is probable that certain of these cases are the result of a slight former hemiplegia, which has manifested itself chiefly in retarding the growth of the affected side without any distinct loss of motor power. This seemed probable in a case recently seen by the writers, in which the right side of the body was distinctly behind the left side in growth, but

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[1] "Asymmetry of the Lower Limbs." etc., Phila. Med. Times, July 10th, 1886.

[2] Boston Med. and Surg. Journal, vol. cvi., p. 462.

[3] Canstatt's Jahresbericht, 1859, vol. iv., p. 6.

[4] Am. Journal Med. Sciences, January, 1886.

[5] Lyon Médical, January 29th, 1888.

[6] Revue de Chirurgie, April 10th, 1888.

the left side of the head was smaller than the right side—a relation which suggested most strongly the existence of some lesion of the trophic centres in the left cerebral hemisphere.

Symptoms and Treatment.—Long-continued slight and oftentimes severe backaches, with lumbar and pelvic pain, involving the distribution of the sciatic nerve, are often due to asymmetry of the lower limbs. Such symptoms are at times at once relieved upon correcting the asymmetry. A person in previous good health may from some depressing physical condition begin to have the above symptoms of pain localized as stated, and upon examination unequal limbs will be found in very many cases.

Morton said that United States pension examining-surgeons stated that many applications for pension have been made for disabilities described as lumbago, supposed to have been caused by exposure or by injuries contracted during the war for the Union. In nearly all such cases an examination revealed a previously unrecognized asymmetry, and the symptoms were probably induced by this defect in development.

Symptoms of inequality of the lower limbs may simulate coxalgia. In such cases the legs should of course be measured. Children complaining of backache, or so-called growing pains, should be carefully examined for any such anatomical defects.

The medico-legal bearing of the fact of asymmetry has been called attention to by Hunt in the paper already referred to.

Hypertrophy of the limbs may occur from two causes, from disease of the vessels or from a congenital tendency.

CHAPTER XXI.

TALIPES EQUINUS AND TALIPES CALCANEUS.

Talipes equinus.—Varieties and symptoms.—"Contracted foot" ("non-deforming club-foot").—Treatment.—*Talipes calcaneus.*—Varieties and symptoms.—Treatment.—*Pes cavus* (pes arcuatus).

Talipes Equinus.

Talipes equinus is the name given to a condition in which the foot is held in a position of plantar flexion and cannot be flexed dorsally to the proper extent. It is known also as pes equinus, horse heel, pied bot equin, Pferdefuss, and Spitzfuss.

Varieties and Symptoms.—As a congenital deformity, talipes equinus is the greatest of rarities but its existence is well established. As an acquired deformity it is very common, especially in its lighter degrees.

Fig. 556. Fig. 557. Fig. 558.

Figs. 556, 557, and 558.—Talipes Equinus.

In the acquired form all degrees are met, from a condition in which the foot cannot be flexed beyond a right angle to one in which the foot and leg are nearly in a continuous line. The deformity, in the lighter degrees, is one of less importance than the other forms of talipes.

A slight degree of this affection may be enough to cause a limp in walking, as in carrying the leg back at the end of the step the foot must be bent more than to a right angle.

The structural changes in talipes equinus are slight. In a large number there is simply a shortening in the Achilles tendon muscles, with a consequent alteration in the shape or relation of the bones of the foot. Some cases, however, are due less to the raising of the calcaneum than to a depression of the head of the astragalus, which may be depressed nearly in a vertical line, and the arch of the foot increased by a strong flexion at the medio-tarsal joint.

The causes of acquired talipes equinus are as follows:

(1) Infantile paralysis of the anterior muscles of the leg.

(2) Cerebral (spastic) paralysis, hemiplegia, pseudo-hypertrophic paralysis, and similar affections causing either loss of power in the anterior muscles of the leg or an overbalancing of these muscles by the contraction of the posterior group.

(3) Shortening of the leg after joint disease or fracture may lead to an adaptive talipes equinus which serves to make the legs of equal length.

(4) Disease of the ankle-joint may have talipes equinus for a symptom.

(5) Long confinement to bed may cause a talipes equinus, which is merely a result of the long-continued plantar flexion of the feet.

(6) Fractures may result in talipes equinus either from injury to the ankle-joint or from fixation during repair in a plantar flexed position.

(7) Hysteria may be a cause.

(8) The contraction caused by posterior cicatrices or the loss of power due to division or injury of the anterior muscles and tendons of the leg may cause the deformity.

In the severer forms there is a marked projection on the dorsum of the foot formed at the site of the calcaneo-cuboid and astragalo-scaphoid articulations. As locomotion occurs only on the ball of the foot, this part becomes abnormally wide, and in time the plantar fascia contracts and resists the reduction of the malposition.

In very severe cases the foot is bent on itself, so that the sole is directed upward and backward, and locomotion takes place on the dorsum of the foot.

The spastic form is most commonly met in spastic paralysis or after hemiplegia. As this is due to the contraction of the muscles of the tendo Achillis, the position of the foot in this differs from that following paralysis. The heel, in the spasmodic form, is drawn upward and the whole foot depressed in consequence. There is, therefore, less tendency to the formation of an angle in the medio-tarsal or tarso-metatarsal joints.

The form often met in shortened limbs, as after recovering from hip disease, fracture, etc., is the result of the maintenance of the foot for a long time in a partially extended position, in the act of walking and standing. In these cases it is a compensatory arrangement, inasmuch as it tends to keep the pelvis level, and not to be regarded as objectionable except in its appearance.

The detection of talipes equinus is so simple a matter that it scarcely needs description. The normal foot should be capable of flexion somewhat beyond a right angle, and any cause which restricts this flexion is a degree of talipes equinus.

"*Contracted Foot*" ("*Non-Deforming Club-Foot*").—One form of a slight degree of talipes equinus deserves separate consideration. It is characterized by a slight or moderate degree of limitation of the normal dorsal flexion of the foot. Shaffer described it under the name of "non-deforming club-foot," and it has also been spoken of as "contracted foot."[1] Apparently it is due to a contraction, often temporary, of the posterior muscles of the leg, chiefly the gastrocnemius, or the muscles of the sole of the foot. It may occur in flat-foot, the weakened foot, and in similar conditions in which it is apparently due to irritation and possibly is reflex in character. The writers have not in most cases been able to regard it as a causative factor in flat-foot, as advanced by Shaffer.

It is often associated with metatarsalgia, possibly as a causative factor, possibly as a result of irritation from the foot. It exists often in sciatica when flexion of the foot beyond a right angle is not only restricted but painful. It sometimes is found in elderly persons in whom it seems to be the result of stiffening and loss of elasticity in the posterior muscles. It exists occasionally in hysterical persons, chiefly in women, without further obvious cause. It may be found in adults or children apparently perfectly healthy in whom no demonstrable cause for it exists. It is found often after sprains of the ankle.

As it is not an obvious deformity it often escapes recognition. The most common symptoms associated with this slight degree of talipes equinus consist in cramps in the calves, especially at night, heaviness and stiffness in the feet in walking, tenderness in the plantar fascia, and often a feeling of tension in the back of the leg and thigh. Backache is not an uncommon accompaniment. All of these symptoms seem to be aggravated by the use of the feet.

On inspection the arch of the foot is seen to be unusually high, the toes may be somewhat "clawed," dorsal flexion of the foot is limited, and when the foot is brought to a right angle a tense and tender band in the plantar fascia is generally found. The examination for dorsal flexion should of course be made with the leg fully extended at the knee.

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[1] Park's "System of Surgery," vol. ii., article "Orthopedic Surgery."

A condition of limited dorsal flexion of the foot associated with an unusually high arch exists, however, in certain persons without giving rise to symptoms.

Treatment.—The treatment of the mildest variety, just described under the name of "contracted foot," consists in seeking for the cause of it and relieving it when possible. If the foot is weak it should be properly supported in a correct position, as will be described in the following chapter. It sometimes affords relief to support a troublesome high arch by a high shank of the shoe or by felt pads or steel plates. The dorsal flexion of the foot may often be restored, in part at least, by means of the shoe devised by Shaffer, which by means of a geared joint at the ankle exerts powerful pressure in the direction of dorsal flexion. The shoe consists of a sole plate, two uprights, and a posterior band. The foot is secured to the foot plate, and dorsal flexion of any degree is secured by turning the key at the ankle, by which the sole plate is flexed on the uprights. In the use of the apparatus Shaffer advises intermittent traction of a force suited to each case. The apparatus should not be used to exert extreme force, but only a degree comfortable to the patient. This method of treatment is of value in relieving the symptoms in many of the cases. In certain cases the symptoms return shortly after the cessation of treatment. In others the benefit seems permanent. In anterior metatarsalgia the increase of dorsal flexibility is often of benefit in connection with the other treatment. The method is useful only in very slight cases of talipes equinus in which dorsal flexion is limited at about a right angle.

A simple appliance may be made by securing the patient's leg to a flat, smooth piece of board, by means of strips of adhesive plaster from the sides of the leg to the bottom of the board. If this board is longer than the foot and is furnished with a strap secured to the projecting end of the board and to a buckle secured to the leg by adhesive plaster, stretching the tendo Achillis can be accomplished by tightening the strap.

When talipes equinus of any but the slightest grade exists the only treatment consists of tenotomy of the tendo Achillis, and of the plantar fascia if that is contracted also.

When the deformity is due to spastic paralysis, simple tenotomy of the heel tendon is sufficient; when there is contraction of the plantar fascia, that should be cut before tenotomy of the tendo Achillis is done, as the contracted heel tendon affords useful counter-pressure in straightening the arch of the foot after division of the fascia.

The deformity should be at once corrected after tenotomy and a plaster-of-Paris bandage applied. If a retention appliance is required after operation, the usual form of club-foot shoe, with the ankle-joint arranged to stop extension at a right angle, will be found to be effectual

and simple. Or a simple foot piece joined to two uprights and a posterior band may be used which is jointed in the same way at the ankle. This prevents the foot from rolling in or out and thus makes the act of walking a force to pull upon the tendo Achillis at each step.

In extremely severe cases a wedge-shaped osteotomy of the tarsus might be required for rectification, but this would be very unusual.

Talipes Calcaneus.

Talipes calcaneus is the name applied to a condition in which the foot is held in a position of dorsal flexion. It is known also as pes calcaneus, pied bot calcanéen, pied bot tabes, and Hackenfuss.

Varieties and Symptoms.—The deformity may exist alone or in connection with valgus, in which case it is known as talipes calcaneo-valgus. It exists occasionally as a congenital deformity in varying degrees. It may be noticed only as a slight prominence of the heel or it may be so severe that the dorsum of the foot lies practically against the shin. No better explanation has been given for its existence than is the case in other congenital deformities.

Acquired talipes calcaneus is most often due to paralysis of the muscles of the calf of the leg due to anterior poliomyelitis. It may also occur in chronic disease of the ankle as a result of muscular irritability. It exists sometimes in hysteria. It may result from rupture or division of the posterior muscles of the leg and from anterior cicatrices.

Ankylosis of the ankle in a deformed position has been recorded in one case.[1]

The deformity is obvious on inspection and requires no description; the patient of course walks upon the heel.

Treatment.—In congenital cases manipulation with daily attempts at rectification by the parents is sufficient to correct the deformity except in the severer cases in which the application of a series of corrective plaster bandages may be necessary. Tenotomy of the anterior tendons is rarely necessary.

When the foot has been reduced to the normal position, and the motion extended to the normal limits, a retention shoe may be applied; but in slight cases this is not necessary.

For retention, a steel sole plate and upright, with a stop at the ankle-joint so as to prevent flexion beyond a right angle, is of value.

The treatment of talipes calcaneus due to infantile paralysis has already been considered.

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[1] Hoffa: "Orthopädische Chirurgie."

Pes Cavus.

(*Pes Arcuatus.*)—In this deformity the anterior part of the foot is drawn backward and the arch increased. All degrees of severity are found, even to a condition in which the ball of the foot and heel

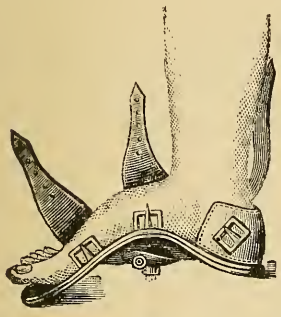

Fig. 559.

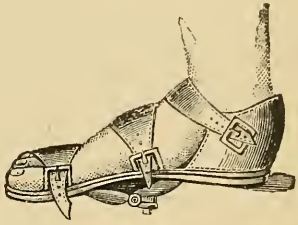

Fig. 560.

Figs. 559 and 560.—Biggs' Appliance for Pes Cavus.

are in contact; and the arch of the foot is converted into a deep sulcus. In an exaggerated degree it is the condition of the feet of high-caste Chinese women. This form is in reality a variety of the calcaneus, to which the cavus has been added.

Three forms of pes cavus are recognized. The first is due to the contraction of the peroneus longus; and the resulting deformity is in conse-

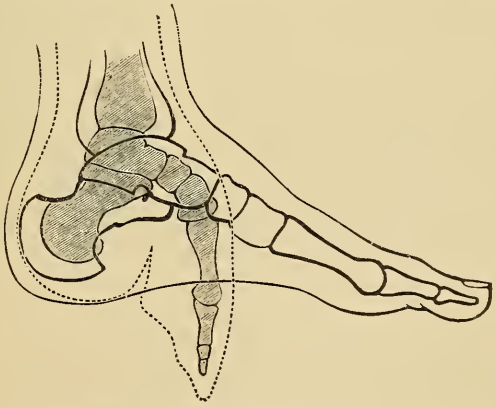

Fig. 561.—Diagram of Position of Bones in Chinese Lady's Foot.

quence of the approximation of its insertion and the heel. The second variety is the result of paralysis of the gastrocnemius and soleus muscles. The sole of the foot is lowered, and by the action of the long flexors on the anterior part a cavus foot is developed. There may be complicated

with this a varus or valgus distortion. The third form may be acquired, but is usually congenital. It has been called by Duchenne "Griffe-pied-creux." The condition results from a marked depression of the heads of the metatarsal bones with a forced extension of the first phalanges and a flexion of the last. The origin of the affection is in a paralysis of the interossei and lumbricoid muscles, and of those muscles which are inserted into the sesamoid bones of the great toe.

Treatment.—It is difficult to correct the deformity of pes cavus by mechanical appliances; the common form of these consists in a steel sole plate with a constricting band over the head of the astragalus.

An ordinary steel sole plate made from a cast of the corrected foot and inserted in the shoe is of assistance.

CHAPTER XXII.

FLAT-FOOT AND OTHER AFFECTIONS OF THE FEET.

The weakened foot.—Anatomy.—Flat-foot.—Pathological anatomy.—Causation.—Symptoms.—Diagnosis.—Prognosis.—Treatment.—Corrective.—Mechanical.—Morton's disease.—Hallux valgus.—Hallux varus.—Hallux rigidus.—Hammer toe.—Deviation of the small toes.—Miscellaneous conditions.

Owing to the almost universal use of shoes and the consequent cramping of the feet, it is necessary, for a study of the normal foot, to examine the feet of infants and of moccasin or sandal-wearing races.

In young infants of normal nutrition the foot seems shorter and thicker than that of the adult or older child. It also appears on superficial examination to have little or no arch.

Fig. 562.—Left Foot of Child Eighteen Months Old. (Dane.)

Fig. 563.—Same, Section at Mediotarsal Joint. (Dane.)

Dane has shown by measurements of the height of the scaphoid above the level of the sole and by hardened sections of the feet of infants that the bony arch of the child's foot is not flattened at birth but that the apparent flatness is due to a pad of fat placed under the arch of the foot.

If the foot of a young infant is examined it will be seen that there is muscular power in the movement of all of the toes. The great toe can

voluntarily be drawn to the inner side, and the fifth toe can be drawn to the outer side by voluntary muscular exertion. The toes can be flexed readily. The second toe is, when stretched to its full length, frequently longer than the first. The third is of the same length as the first, the fourth is somewhat shorter, and the fifth, though shorter, is but slightly so. None of the toes remain permanently curled, though when in a relaxed condition the terminal phalanx drops somewhat and the smaller toes curl. A separation between the first and second toe is normal. When the muscles are active the great toe is drawn to the inner side frequently. The line of the extremities of the toes presents

FIG. 564.—Ordinary Type of Foot Imprint in Infants.

FIG. 565.—Egyptian Statue, British Museum, Showing Straightness of Toes

a gradual curve with the greatest forward convexity at the tip of the second toe. The line of the inner edge of the foot is always straight except when there is contraction of the muscles.

If the undisturbed adult foot which has never worn shoes be examined, it will be found to present many of the characteristics of the infant's foot, but there is greater muscular power in the toes and foot and rela-

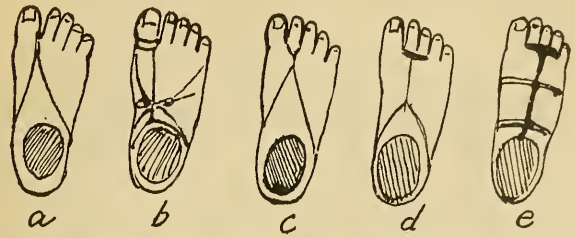

FIG. 566.—Inter-toe Thongs Retaining Sandals. *a*, Egyptian, Japanese, etc.—between first and second toe; *b*, Chaldean—thong around first toe; *c*, Somali—around second toe; *d*, Toltec—around second and third toe; *e*, early Etruscan—around second, third, and fourth toes.

tively less fatty tissue. The flexibility of the front of the foot is great, and can be increased by training.

The injurious effect of shoes upon the foot can be seen by comparing the flexibility of the front of the normal foot of infants with that of the ordinary shoe-wearing individual. It will be found that the flexibility of the toes is impaired and the power voluntarily to adduct the great toe and separate the fourth and fifth toes is either lost or mate-

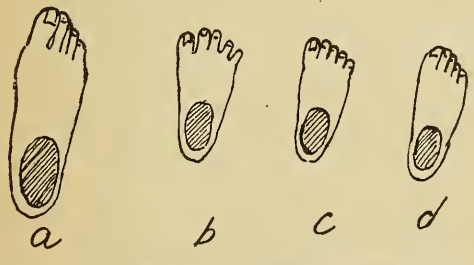

FIG. 567.—Feet as Seen among Shoe-wearing People with Little Distortion. *a*, Adult—first and fifth toe slightly crowded by shoes; *b*, infant—toes extended by muscular action; *c*, infant—muscles relaxed; *d*, slight crowding of toes—from shoe—in a child.

FIG. 568.—Greek Sandal with Intertoe Straps, Side Straps Compressing Little Toe.

rially diminished. The front of the foot is compressed by shoes and its functional power lessened.[1]

The effect of impairment of the muscular power of the muscles of the

[1] An examination of the foot as represented in art shows that the foot, though imperfectly modelled, is near to the normal type in Egyptian sculpture; is nearly normal in Greek art, except in the distortion of the fifth toe, from the cross sandal strap; in the art of the Renaissance the distortion of the first toe, known as hallux valgus, and a weakened position of the foot are frequently seen, and this is also true of modern sculpture (Orthop. Trans., vol. x., p. 148).

sole of the foot and the muscles controlling the toes is to develop a pathological condition which may be described as weakened foot.

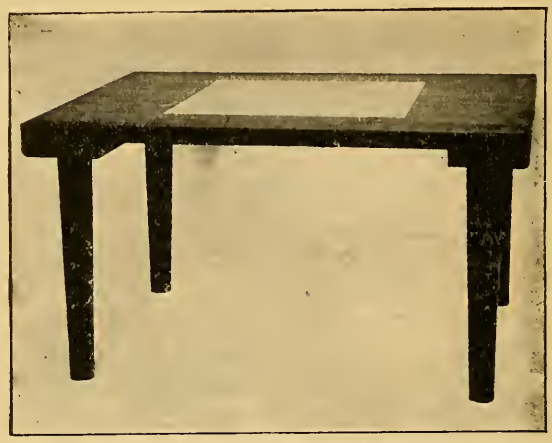

FIG. 569.—Table with Glass Top for Examining Feet.

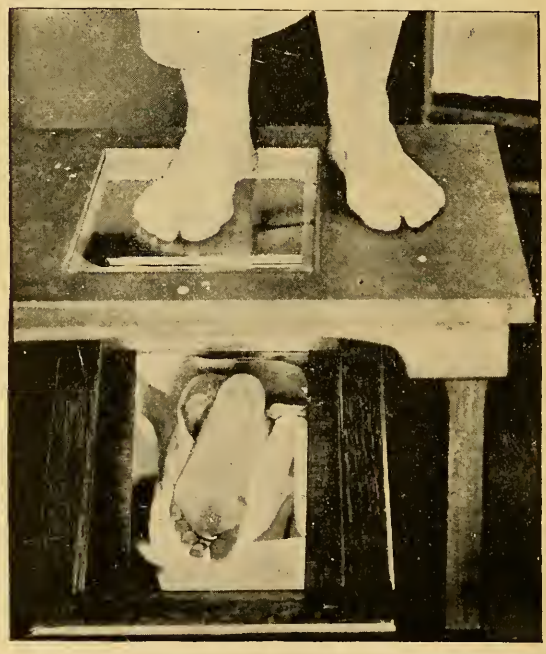

FIG. 570.—Glass Table for Examining, in Use with Mirror.

THE WEAKENED FOOT.

By the weakened foot is meant a foot which in ordinary standing habitually assumes that faulty attitude in which it rolls over inward, the

inner malleolus projects, and abduction of the front part of the foot occurs. Up to a certain limit this movement occurs in the normal foot; beyond this limit it must be regarded as pathological, and is likely to be attended by symptoms of pain and disability. This condition can be observed if the patient suffering from weakened foot stands on a piece of plate glass and the surgeon, looking into a mirror placed obliquely underneath, sees the contact of the foot with the glass as a dead white area where the pressure is greatest, and as a less anæmic area where the pressure is less. There is no difficulty in distinguishing the line of contact

FIG. 571.—Type of Tracing Described as Normal.

of the foot with the glass. In the normal foot not bearing excessive weight, the inner border of the great toe, the inner malleolus, and the inner condyle of the femur should all be in the same vertical place. A certain amount of yielding is normal under weight-bearing, but in the weak or overweighted foot the foot, by this movement carried to excess, is displaced too much outward in its relation to the leg.

When the whole weight of the body is thrown upon a limb, the foot being planted firmly upon the ground, the whole leg rotates inward at the hip. The inner malleolus moves inward, downward, and backward; the outer malleolus forward; the whole foot rolls over somewhat to the inner side.

This movement is made possible (while the heel and front of the foot

are firmly supporting weight) by motion at the medio-tarsal articulation. When the muscles and ligaments checking this motion are weakened, the movement at the medio-tarsal articulation becomes exaggerated and the anæmic portion seen in the mirror as the patient stands on glass changes in shape from that seen in a normal foot.

FIG. 572.—Diagram Showing Composite Character of Imprint Tracings. Dotted line shows weakened position.

The inward rolling of the foot is also shown by a foot impression upon paper blackened by smoke, though with less accuracy than when seen as described in the mirror. The impression of the foot bearing but little weight and that of one bearing increased weight differ normally, but the difference is greater in a foot in which the muscles are weakened.

When this position consequent upon a weakened condition of the foot is constantly taken by prolonged standing, it produces an abnormal strain not only on the muscles and ligaments of the foot but upon other muscles, as has been shown by Dane,[1] who formulates his conclusions as follows:

"1. In 'pronation of the foot' the greater part of the foot remains stationary and the leg rotates upon it.

FIG. 573.—Outline Drawing (from Photograph), Showing Inward Excursion of Internal Malleolus in Pronation.

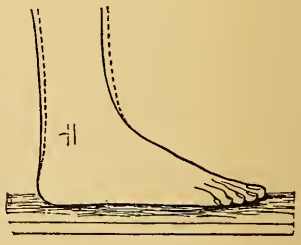

FIG. 574.—Outline Drawing (from Photograph) in Normal and Pronated Position, Showing Forward Excursion of Mark over External Malleolus in the Pronated Position.

[1] John Dane: Orth. Trans., 1897.

"2. In addition to the generally recognized motion of the malleoli inward and slightly downward, the normal outward rotation of the tibia and fibula is replaced by an exaggerated rotation inward which takes place about a nearly vertical axis located near the inner border of the tibia.

"3. These changes acting together produce an alteration in the obliquity of the axis of flexion of the ankle-joints sufficient to destroy the mechanism by which the normal joints are enabled to support the body weight with a minimum of muscular exertion. As a consequence, flexion must be prevented and equilibrium maintained wholly by muscular force, which soon leads to irritation and fatigue of all the muscles of the lower leg, and especially of the peroneus longus.

"4. This inversed rotation of the tibia interferes to a great extent with the operation of the mechanism by which complete extension of the knee should lock the joint and render it proof against the constant tendency of the body weight to flex it. The knee must, therefore, in subjects with pronated feet, be kept in extension by a constant exercise of muscular force which results in the fatigue and tendency to tonic spasm of the muscles of the thigh. This is shown also by the extreme tenderness often found over the point of insertion of the internal hamstring muscles on the inner tuberosity of the tibia.

"5. Owing to the constant attempt of the muscles on the outer side of the thigh to prevent the internal rotation of the lower part of the leg they are commonly found to be tense and sensitive to pressure.

"6. To try and compensate for this inversed rotation of the tibia and fibula there is an exaggerated inward rotation of the femur. This in its turn overstretches the external rotators of the hip, as shown by sensitiveness to pressure and tonic spasm of the glutei, and tenderness over the points of exit of the sacral nerves.

"7. Lastly, this explanation is wholly in accord with the clinical fact that when we have, by means of efficient mechanical support, prevented 'pronation of the foot,' we have relieved the pains in the calf, the knee, and the hip."

Anatomy.—Investigations of the anatomical changes in the positions of the bones of the foot involved as weight is thrown upon the limb have been made by a number of observers, especially by Meyer[1] and Golobiewski.[2] To illustrate this still further, skiagraphic observations were made by one of the writers.[3] The feet were photographed in two or three directions, from the inside, from above, and from the outside;

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[1] "Statik und Mechanik des menschl. Fusses."

[2] Zeit. f. orth. Chir., 1894, iii., 243.

[3] R. W. Lovett and F. J. Cotton: Trans. Am. Orth. Assn., vol. xi.

when correction was possible, the same foot was photographed in the two positions of supination and pronation (that is in the normal and weakened position).

In photographing the two positions the foot was allowed to sink or was corrected to the required position, and a fresh plate was adjusted

FIG. 575.—A very Mobile Foot. Full line shows position of supination; dotted line that of voluntary pronation. No symptoms.

and exposed in the same place, neither the sole of the foot nor the tube being moved. In all cases a definite measured distance of the tube from

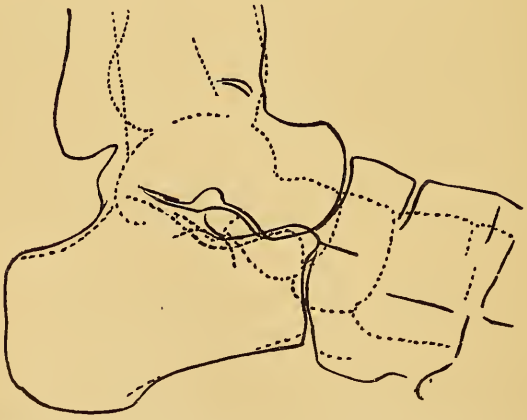

FIG. 576.—A Painful Weakened Foot (X-ray Tracings). Dotted line shows standing position; full line that of voluntary correction.

the plate was used, and the foot was placed in constant relation to both. For the lateral views the tube was placed at the height of the astragalus; for the views from above, the centre of the tube was placed directly over

the centre of the front edge of the plate. The views were taken with the foot in a position of slight toeing-out, and as nearly as possible with each foot bearing an equal part of the body weight.

In this way there was obtained a series of negatives in which the error of distortion seems to have been reduced to a minimum; for whatever distortion was present, under this constant relation of distance and

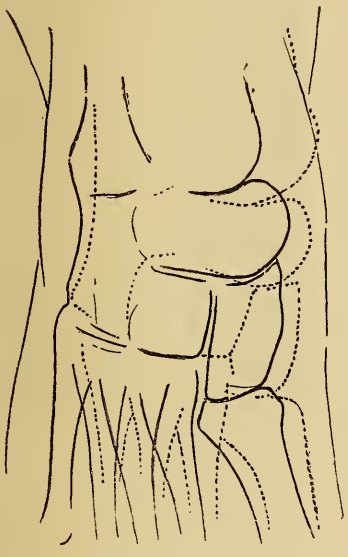

FIG. 577.—A Painful Pronated Foot (X-ray Tracings). Standing position shown in dotted line: full line shows voluntary correction.

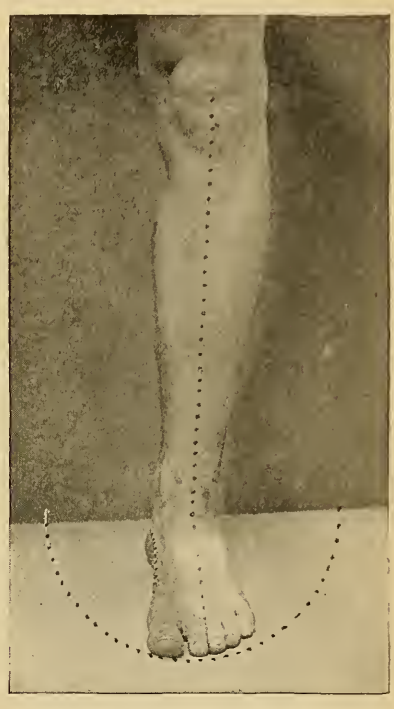

FIG. 578.—Voluntary Protection against Strain. Normal standing position. (Whitman.)

angle, must be approximately reproduced in each and every plate. The plates were compared by overlaying accurate tracings of the negatives, a method which proved much more serviceable than the use of prints, or of the negatives themselves. Forty-four negatives were taken, of which forty-one proved available for comparisons.

It was found that a rotation of the whole foot takes place beneath the astragalus toward the position of valgus. This is seen on the *x*-ray plate of the lateral view by comparison of the relations, in the two positions, of scaphoid and cuboid, and is also obvious in the view from above. The valgus rotation of the calcis is best seen in side view by comparison of the relative positions of the sustentaculum tali and the line of the upper surface of the calcis. The maximum extent of this rotation was in

one case about fourteen degrees. This was readily determined by setting up dry bones to correspond to the positions indicated by the tracings.

The astragalus so rotates in pronation that its head moves inward and backward, its body and outer portion outward and forward. This is obvious in the bone itself, and is accompanied by the very obvious change in position of the malleoli, which, of course, move with it in this

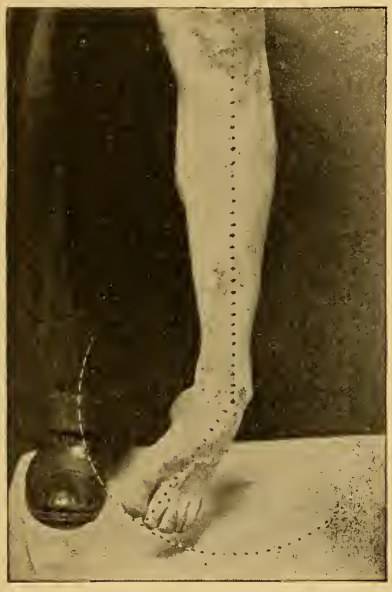

FIG. 579.—Voluntary Adduction. (Whitman.)

FIG. 580.—Voluntary Abduction. (Whitman.)

rotation, the inner malleolus backward and the outer forward. There is at the same time a plantar flexion of the astragalus by which its head sinks toward the sole.[1]

There is some movement outward of the cuboid on the calcis, hard to estimate accurately by the *x*-ray on account of the irregular contours of the bones.

Associated with this is a movement outward of the front-foot, taking place between the scaphoid and the astragalus, by which the head of the astragalus, rotating inward, is in part exposed.

Anterior to this point no change of relation of the bones is to be made

[1] All these movements have been recognized and described as occurring in the movements of the normal foot (v. Meyer: "Statik u. Mechanik des menschl. Fusses"; Golobiewski: Zeit. f. orth. Chir., 1894, iii., 243).

out, the whole front-foot, including scaphoid and cuboid, moving essentially *en masse*.

The results of the *x*-ray studies were checked by anatomical observations, not only of dry bones, but of the cadaver in various stages of dissection. The material placed at our disposal by Dr. Thomas Dwight did not consist, it may be said, of dry or drying specimens, but of either alcoholic specimens of ligamentous dissections, or of dissections of relatively fresh cadavers, moistened to a practically normal flexibility. To determine the movement of the bones one upon the other, long pins were driven into each of the various bones, and, with the foot bearing weight, the positions of pronation and supination were produced. The movements of the free ends of the pins gave a correct means of determining the movements taking place between the bones, and a very close correspondence in detail was found with the results of the *x*-ray photographs. Only in one respect was there a difference worthy of note: in the cadaver less valgus rotation of the calcis and more motion between the cuboid and os calcis were found under similar conditions than the *x*-ray photographs had led us to expect.

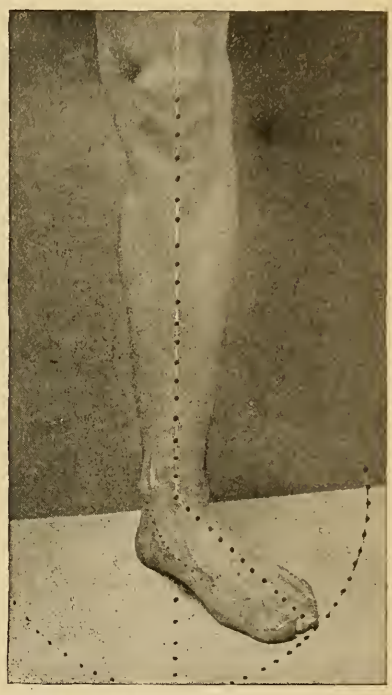

FIG. 581.—An Attitude that Simulates Flat-foot. (Whitman.)

The abduction of the front-foot is not directly dependent on the rotation of the calcis, but rather upon the horizontal rotation of the astragalus. The head of the astragalus, which is roughly spherical, moves in a ball-and-socket joint formed by the sustentaculum tali, the calcaneo-scaphoid ligament, and the scaphoid. This allows of free movement, but the relations of surface are such that an inward rotation of the head of the astragalus (when the foot is under weight) determines an outward movement of the scaphoid swinging on the calcaneo-scaphoid ligament. Conversely, if the relation of the scaphoid to the calcis is fixed, with the foot bearing weight, no inward rotation of the astragalus is possible. It is in this way rather than by supporting the head of the astragalus directly, as is sometimes stated, that the tibialis posticus prevents pronation. This may readily be shown in the cadaver by nailing the tendon of this muscle to the tibia, when pronation is checked. Conversely, in

some specimens in which the muscles and tendons are intact, pronation is limited by this muscle, and if its tendon is cut or slipped from its groove, pronation to a much greater extent is possible.

This somewhat complicated relation between astragalus, scaphoid, and ligaments also determines the mechanism by which the front part of the foot-sole is kept flat to the ground. As the foot is supinated, there is a movement downward of the scaphoid over the head of the astragalus as well as the movement inward just described. When the foot is rolled outward in supination, this plantar flexion of scaphoid, cuneiform, and inner metatarsals acts to compensate, and the inner side of the ball of the foot still remains in contact with the ground. This compensation has a practical bearing.

It is to be noted that the astragalus has no muscular insertions and acts simply as a transmitter, and the sole transmitter, of the body weight. Once movement of the astragalus is permitted by the muscles, its movements and the movements of the tarsal bones beneath it are determined only by the relations of the joint surfaces—though ligaments may limit their extent.

To sum up, the movements in question consist of the horizontal rotation of the astragalus with the sinking of its head, the rotation in valgus of the calcis beneath it, and the rotation in valgus and abduction of the front-foot as a whole, occurring between astragalus and scaphoid, calcis and cuboid.

When the condition herein described becomes more developed, structural changes take place, and what has been termed acquired valgus or flat-foot exists. This differs from a weakened foot in the severity of the distortion and in changes which take place in the impairment of the elasticity of the ligaments, in changes in their length, and in prolonged and severe cases in the shape of some of the tarsal bones.

Flat-Foot.

Flat-foot or talipes valgus is a deformity characterized by a marked pronation of the foot with obliteration of its arch. There is also abduction of the front part of the foot.

The deformity is also called splay-foot; in German Plattfuss and in French Pied bot valgus, pied plat: it is also sometimes called pes pronatus.

The affection is either congenital or acquired.

Congenital talipes valgus is not an extremely rare affection. Küstner[1] examined, with regard to this, 150 new-born children consecutively, and 13 (8.6 per cent) of these presented marked congenital flat-foot; that is,

[1] Archiv f. klin. Chir., 1880, 25, p. 397.

the sole of the foot was convex and the whole foot pronated or rolled out. Sometimes there is present congenital calcaneo- or equino-valgus. Adams found 42 cases of congenital valgus in 764 cases of congenital deformity of the feet; in 15 others there was varus of one foot and valgus of the other. Of the 42 cases, 15 were of the right foot, 10 of the left, and 17 of both.

The characteristics of the deformity of congenital valgus are a strongly pronated and abducted position of the foot relative to the axis of the leg.

FIG. 582.—Typical Flat-foot of Moderate Degree. (Whitman.)

Frequently two projections can be seen on the inner side of the foot corresponding to the head of the astragalus and the side of the scaphoid bone.

Absence of the fibula and defective development of the external malleolus are congenital deformities at times associated with congenital valgus.

PATHOLOGICAL ANATOMY.

The anatomical changes are much the same in congenital and acquired talipes valgus.

The bones in congenital flat-foot even in severe cases show but little alteration in shape. The astragalus is turned obliquely to one side and downward, and the angle of the articulation faces more to the side than is normal. The end of the os calcis may be slightly raised. The scaphoid is turned to the outer side and is rotated somewhat on its central axis, so that the outer side is slightly raised and the inner side is lowered —the arch of the foot is obliterated and the inner border is often convex rather than concave.

In acquired flat-foot the anatomical changes show very few alterations in the shape of the bones in light cases. The astragalus is turned obliquely forward and downward and its head altered in position, so that its face

is on the outer side; the scaphoid is rotated, and its outer side raised. Slight alterations in the shape of the bones are noted, and in severe cases the external malleolus is somewhat flattened and rounded. In

FIG. 583.—Rigid Flat-foot. (X-ray tracing.)

severe cases there is practically almost complete dislocation of the scaphoid outward, and sometimes there is a formation of osseous deposit which

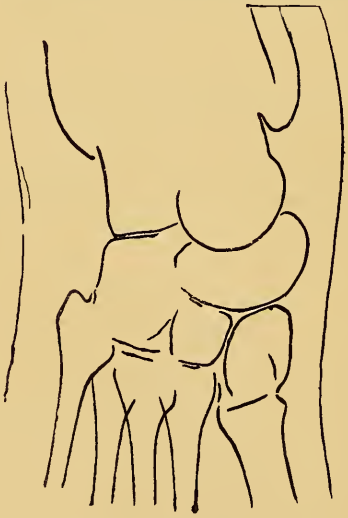

FIG. 584.—Rigid Flat-foot. (X-ray tracing.)

prevents the normal amount of play between the scaphoid and astragalus. Alterations in the shape of the sustentaculum tali and of the astragalus as it articulates with this are also noticed.

Of the ligaments the most important are the inferior calcaneo-scaph-

oid and the calcaneo-astragaloid. The latter of these does more to keep the "keystone" of the arch in place than does any arrangement of its

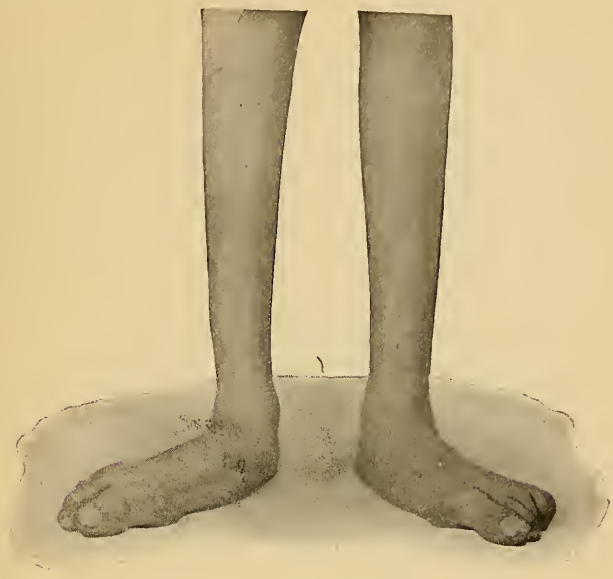

FIG. 585.—Flat-foot.

components. In the maintenance of the normal concavity all the ligaments of the sole of the foot contribute, but to a less extent.

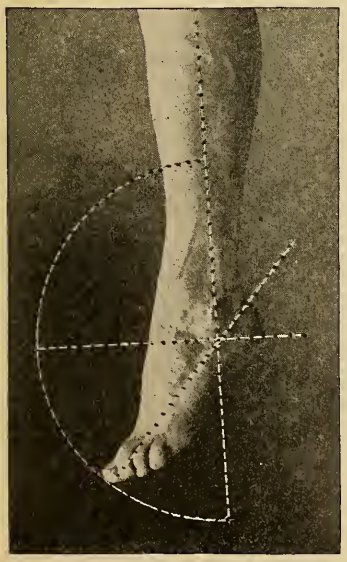

FIG. 586.—Voluntary Plantar Flexion (Normal). (Whitman.)

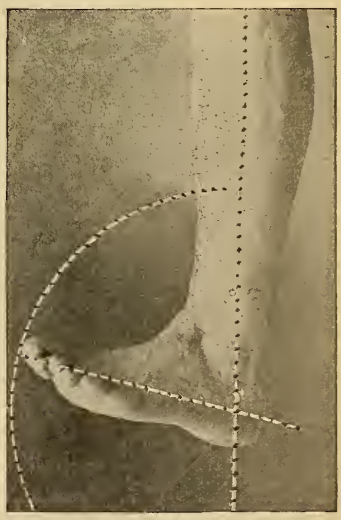

FIG. 587.—Voluntary Dorsal Flexion (Normal). (Whitman.)

In severe flat-foot, owing to the change in the form of the bones, there is a limitation in the amount of motion at the ankle-joint. The normal

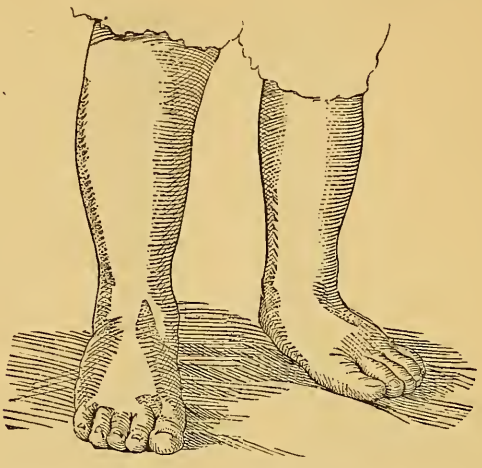

FIG. 588.—Flat-foot Occurring in a Young Rhachitic Child.

amount of motion which should be from 76° to 80°, in flat-foot may be restricted to 45° or even 32°.

Varieties of flat-foot are described and two may be mentioned.

The rhachitic variety is chiefly seen in connection with other evi-

FIG. 589.—Flat-foot.

dences of rickets. It may be found associated with knock-knee, and the coincidence is so common that it has been regarded as one of the causes of knock-knee, but it may also be seen in the very early stages of rickets

before osseous deformity is marked. Rhachitic valgus is seen usually before the seventh year.

Traumatic or Inflammatory Flat-Foot.—The class of flat-foot due to miscellaneous causes is not very extensive or very commonly encountered. The most common of traumatic causes is Pott's fracture, in which a valgus is the result of inefficient treatment or of a very severe and intractable fracture. As a result of ankle-joint disease accompanied by considerable destruction of tissue one sometimes sees very marked flat-foot, which does not tend to grow worse because there is generally firm ankylosis in the ankle; but the deformity may be severe. Injury of the long peroneus may give rise to this deformity without any other cause.

Causation.

In general terms, it may be said that the deformity is caused by a disproportion between the weight to be borne and the muscular power which bears it. The occurrence of the deformity is rendered more likely by the shape of modern boots. The immediate causes of the condition are the following, in the order of their approximate importance:

1. Boots of improper shape.
2. Weakness or insufficiency of the muscles resulting from—

(*a*) Long standing, especially on hard-wood floors.
(*b*) Rapid growth.
(*c*) Poor health or muscular debility.
(*d*) Convalescence from acute illness.
(*e*) Rapid gain of weight.
(*f*) Accident or injury causing disuse of limb and subsequent muscular weakness.

3. Excessive strain, as in the case of professional strong men and jumpers.
4. A shortened condition of the gastrocnemius muscle, as described by Shaffer. Unless dorsal flexion of the foot beyond a right angle is possible, it is impossible for a person to complete the step with the leg straight behind him and the foot pointing forward. Eversion of the foot is necessary, and a completion of the step by rolling over on to the inner side of the foot. This, of course, tends to produce pronation and breaking down of the arch.
5. Rickets, for the most part to be observed among children.
6. Infantile paralysis.
7. Direct traumatism.
8. Locomotor ataxia and similar organic nervous diseases.
9. Gonorrhœal rheumatism and rheumatoid arthritis.

The condition is often associated with neurasthenia, although it cannot be put down as the direct result of it.

The most common cause is the weakening of the muscles of the foot by shoes. Shoes as worn by the leisure class or by the class that gain their livelihood (as is the rule in cities) by occupations which require standing rather than strong and vigorous walking, compress the front of the foot. This part of the foot, from compression and from resulting weakness, cannot adapt itself as greater weight is thrown upon the foot, and the medio-tarsal twisting takes place which in the strong bare foot is prevented chiefly by the action of the tibial muscles and by the muscles

FIG. 590.—Weakened Foot without Breaking Down of Arch.

of the first metatarsal and its phalanges. People the front of whose feet have been compressed stand and walk with a greater angle of divergence of the axes of the feet, which increases the danger of the development of the deformity by bringing greater strain upon the inner side of the foot and favoring the inward rolling which frequently develops flat-foot. Flat-foot is not commonly developed among moccasined savages who use their feet actively as hunters, using the muscles of the front of the foot freely.

SYMPTOMS.

The physical signs by which flat-foot is recognized will be better appreciated by a glance at the figures than by any amount of verbal description. Instead of the normal arching upward of the inner border of the foot this border either lies flat on the ground or in a varying degree it is less arched than is usual. The foot has the appearance of being not only broad, but also abnormally long; it is more or less everted, and in severe cases the head of the astragalus and the scaphoid tubercle form a marked bony prominence at the middle of the inner border of the foot.

Occasionally on inspection it seems as if a foot were normally arched, but when a tracing of the foot print is made it will be seen that the inner border of the foot is less a curved line than it should be. The inner malleolus is more prominent than it should be, and, of course, nearer to the ground—the whole foot, in fact, is in an altered relation to the axis of the leg. It seems to have been distinctly displaced outward.

In severe cases the inner border of the foot presents a convex outline

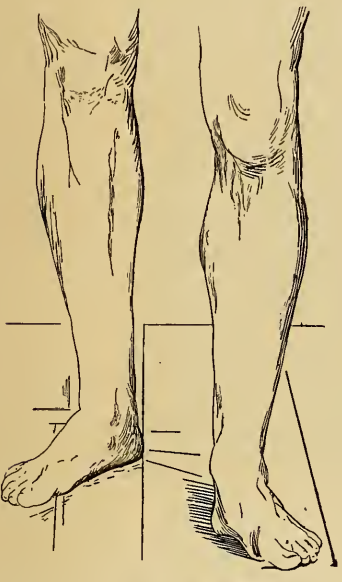

FIG. 591.—Improper Attitude of Eversion of the Feet. (Whitman.)

FIG. 592.—Involuntary Adduction of the Right Fore-foot in the Proper Attitude. (Whitman.)

and the outer border is raised so that the weight is transmitted more improperly than ever. This elevation of the outer border of the foot is the result of a contraction of the peronei muscles and ultimately of the gastrocnemius, the result of long-continued reflex irritation.

Manipulation of the foot is sometimes not attended with pain, at other times any attempt at replacement is very uncomfortable to the patient. As a rule, in slight cases it is possible to return the foot gently with the hands to a correct position, when the weight is not borne upon it. In severe or long-standing cases it is not generally practicable to rectify the foot without the administration of ether and the use of considerable force.

Tender points are almost constantly present in marked flat-foot. These points are commonest over the astragalo-scaphoid articulation at the inner border of the foot, in front of the internal malleolus, and at the base of the first and fifth metatarsal bones. A less common point is to be found in front of the external malleolus. A tender point which

may be the source of much discomfort is often found under the heel at the anterior end of the os calcis. These tender points may become sen-

FIG. 593.—Tracing of a "Flat-foot." No symptoms.

sitive to pressure and to weight-bearing. In acute cases there may be swelling, localized heat, and redness of the skin.

The feet in this condition are apt to perspire profusely, and a conges-

FIG. 594.—Flat-feet (Imprint).

tion is noticed, and in long-continued cases the thickening and vascularity of the superficial tissues may be very marked. Swelling of the feet and

legs is often an accompaniment of severe cases and may become very troublesome. The gait is characteristic in a measure, as the feet are generally more everted than normal, and in painful cases it will be noted

a *b*

FIG. 595.—*a*, Flat-foot; *b*, flat-foot with eversion. (Children's Hospital Report.)

that in standing the patient deliberately throws the foot over, so that the weight is borne more upon the inner border than is normal. There is a lack of elasticity to the gait, and this is a symptom often complained of by the more intelligent patients who find their feet stiff and clumsy. After the patient has been sitting still for some time and on rising in the morning the feet are likely to feel stiff and clumsy.

After standing upon the feet for any time, pain comes on and becomes so severe that it shoots up the legs, sometimes even as far as the thighs. It is somewhat lessened by sitting down, but when once it is present, it is likely to last for many hours. It continues into the night and may be so severe as to prevent sleep. The pain does not necessarily correspond to the amount of deformity present.

FIG. 596.—Boot for Left Foot Worn by Patient with Severe Flat-foot, Showing Characteristic "Treading Over" of Shoe.

A wearing away of the leather of the boot over the inner malleoli in walking may be a symptom to attract attention. Other people notice the prominence of the inner malleolus, especially in children, and the abnormal position of the foot, before feeling pain.

The dorsal flexion of the foot may or may not be limited at this stage of the affection.

More or less unusual symptoms are as follows: pain and a feeling of strain at the origin of the peroneal muscles or at the insertion of the hamstring tendons. Pain and irritability of the knee and sometimes recurring attacks of synovitis of the knee. Backache must also be mentioned as an occasional symptom of flat-foot.

The symptoms here mentioned are also seen in a weakened foot, but in a less degree. There is less stiffness in a weakened foot than in a

FIG. 597.—Weakened Foot.

flat-foot with structural changes. The amount of pain, however, is not always in proportion to the deformity or stiffness.

The symptoms may begin suddenly or gradually. Sometimes, when it is evident that flat-foot must have been present for a long time, pain and tenderness will suddenly come on, perhaps spontaneously or perhaps immediately after some slight wrench or twist of the foot in walking.

DIAGNOSIS.

The diagnosis is to be based upon inspection both with and without the mirror view of the sole of the foot and on the record of the foot tracing. The degree of flexibility of the foot at the medio-tarsal articulation is a measure for distinction between a weakened and a flat-foot.

PROGNOSIS.

After a time the foot may become accustomed to its altered position and painful symptoms cease. In other cases, however, the painful symptoms continue and become worse rather than better as years go by.

The condition may persist almost indefinitely, a constant source of pain and disability.

The results of treatment are immediate and generally satisfactory. In cases with little permanent distortion but great muscular weakness benefit and cure can be expected from careful treatment. In cases of average severity, relief can almost always be given by very simple measures. A spontaneous cure is not to be expected.

Even after deformity of the bone takes place and the distortion is confirmed, a useful foot may be obtained if the muscular development of the leg is good. A prominent "sprint" runner with a fine record of success showed on examination by Dr. D. A. Sargent, of the Hemenway Gymnasium, well-marked flat-foot.

The prognosis of a valgus deformity from inflammatory or paralytic causes varies necessarily according to the nature and degree of the original affection.

Little need be said of the spastic, paralytic, traumatic, or inflammatory forms of valgus. The distortion resembles that of other forms, and the requisite treatment is to be conducted on the same principles as are needed for the ordinary varieties of flat-foot.

Treatment.

The treatment of the conditions described will depend upon the nature of the deformity, its severity, and its duration.

The principles of treatment are simple and consist of the rectification of the foot if distorted, support of the foot in a proper position (if support is needed), and the development of the strength of the muscles and tissues until they are sufficient to maintain the normal attitude. These measures are corrective and mechanical.

Forcible Correction.—In cases in which it is not possible to place the foot in an approximately correct position on account of stiffness and muscular contraction it is generally unsatisfactory to attempt the use of a support until the position of the foot has been corrected. Such patients should be anæsthetized and the foot forcibly twisted into shape. It must be remembered that there are two elements of deformity to be corrected: first, eversion of the foot, and, second, abduction of the fore-foot. This can be done manually in most cases, but in severe cases such an appliance as the Thomas club-foot wrench will be of use in giving better leverage.

The foot should be over-corrected if possible, or in any event placed in the best obtainable position and held by a plaster bandage. It then follows the course of an ordinary sprained ankle, generally of slight degree. As soon as the patient can walk without pain supports should be applied.

In less severe cases correction can be gradually accomplished by the repeated application of plaster-of-Paris bandages.

In extreme cases osteotomy of the neck of the os calcis and astragalus may be needed, but such cases are infrequent.

Mechanical treatment varies from the use of appliances including the leg to that of supports for the arch of the foot.

In the severer forms, especially when paralysis of certain of the muscles is present, when there is decided eversion of the foot, a support holding the leg is needed. Such may be afforded by means of steel sole plates, with an upright passing on the outside of the leg, with a supporting strap around the inner malleolus described in speaking of infantile

FIG. 599.—Flat-foot Plate. Right Foot.

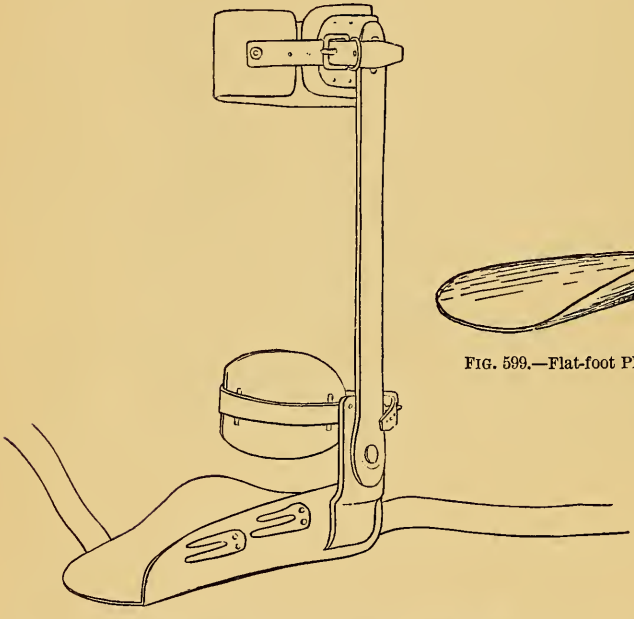

FIG. 598.—Valgus Shoe for Paralytic or Severe Cases.

paralysis. This is the ordinary valgus appliance, worn on the outside of the foot with a leather support over the inner malleolus and secured to the upright.

A form of apparatus has been employed depending upon pressure on the malleolus by a padded plate attached to uprights running up from the sole of the shoe. Supports to the arch of the foot need to be firm and unyielding in the more severe forms. These are best made of steel shaped upon a cast of the foot. The object of the plate is to support the arch by pressing on the head and neck of the os calcis, astragalus, the scaphoid, and, in some instances, the first metatarsal upward and outward. It is necessary that the projecting portions of these bones, but little covered by flesh, should not be unduly pressed upon, and

plates therefore vary according to the individual and the part of the foot most in need of support.

The various shapes of plates that the writers have found of use are shown in the figures. The plate should fit the arch evenly and smoothly and the pressure should be evenly distributed. Some outward thrust from the inner surface of the plate is needed over the inner surface of the astragalus. A high inner edge in front of this is not essential.

The "balance" of the plate is an important matter. Either it should rest securely in the sole

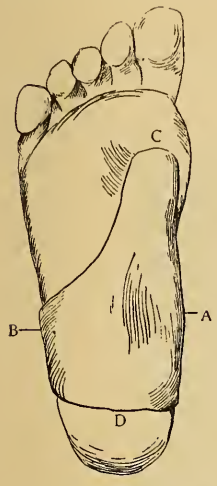

FIG. 600. — Whitman's Flat-foot Plate. *C*, Great toe-joint; *D*. centre of the heel. (Whitman.)

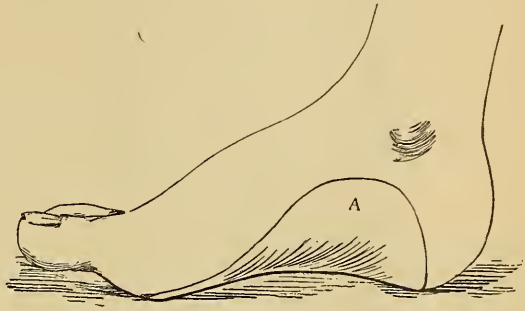

FIG. 601.—Same. *A*, Astragalo-scaphoid Joint.

of the boot or if it tilts at all it should be so arranged that when weight is borne upon it, it rolls the foot on to its outer border as in the Whitman plate. A flange rising from the plate at the outer border of the

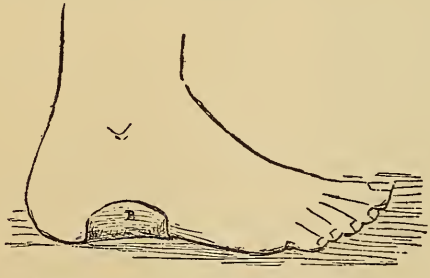

FIG. 602.—Same. *B*, Calcaneo-cuboid Junction.

foot is often of assistance in keeping the foot from sliding off the plate and, if properly placed, counteracts abduction of the fore-foot.

The most useful material from which to make plates is tempered spring steel of the requisite thickness. It may be protected from rusting by being copper-plated and then nickel-plated. Paint, japan, etc.,

as protectives are unsatisfactory unless applied over nickel. Hard-rubber has been used as a covering. Such steel plates are rigid except for a very slight elasticity. Thin tempered steel strips may be embedded in leather soles, and if properly shaped, are efficient in the milder cases. It is not generally possible in this way to secure such accurate support in irritated feet as by a more rigid plate.

Phosphor bronze has been used for foot plates. It is more malleable and more easily fitted, but plates sufficiently thick are much heavier

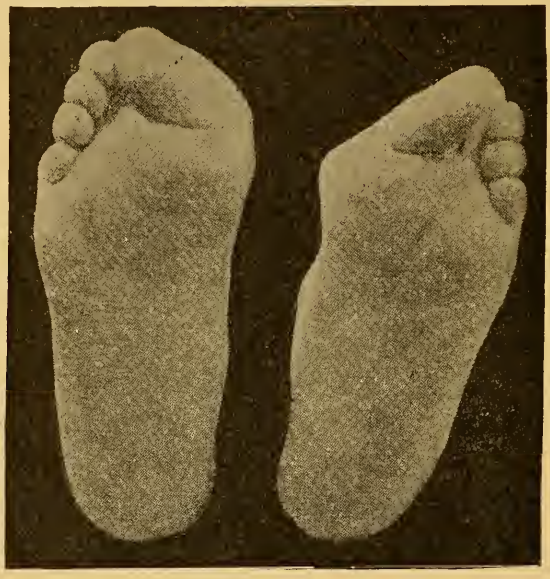

FIG. 603.—Photographs of Casts of Feet Distorted by Improper Shoes. (Walsham.)

than if made of tempered steel and are more inclined to yield under weight.

Aluminum and nickel aluminum are light but not sufficiently rigid and corrode easily. Celluloid has been used with fairly satisfactory results. Vulcanized hard-rubber makes a light and comfortable plate, but it is thick and breaks easily.

To manufacture a plate a plaster cast is essential. This is best taken as follows: Plaster-of-Paris and water are mixed until a consistence is obtained like that of melting ice-cream. This is poured into a box or oblong pan, and the patient sitting in a chair allows the foot to rest on the plaster without bearing weight on the leg. The plaster is heaped up at the inner border of the foot to the level of the scaphoid. When the plaster has hardened the foot is withdrawn, the mould painted with shellac, which is allowed to dry, and the surface of it is wiped with a

greased rag. It is then filled with plaster cream. The cast thus obtained represents the foot in a partially corrected position.

If the plate were made to fit this it would only support the foot in a partially corrected position. To secure the pressure of the plate where desired the cast is then cut away by a knife at the points where greatest pressure is wished and the plate is fitted to the remodelled cast.

In milder cases a less rigid support can be used, such as pads of felt. Felt pads may be cut from boiler felt, reaching from in front of the heel to just behind the head of the first metatarsal, highest at the inner border and sloping not only to the outer border of the foot but backward and forward as well. This may be accomplished by superimposing several layers, each of smaller size than the preceding, on each other. The pad is applied over the stocking and held in place by a turn of bandage, or it may be incorporated in an inner sole of leather. Leather pads may be used in the same way.

The Acute Weakened Foot.—Certain cases are characterized by such acute sensitiveness that a rigid support cannot be applied; neither in many cases is the patient able to rest. The support most likely to be tolerated by such patients is a felt pad applied to the bare foot over which are put strips of surgeon's adhesive plaster in the manner described by Gibney as Cottrell's method for use in sprained ankles. The pad is put in the hollow of the foot, the foot held in a position of talipes varus, and strips of one inch wide are tightly wound around the foot beginning at the outer border passing under the sole and up the inner border of the foot to a point above the ankle; over this is applied a snug cotton bandage.

FIG. 604.—Boot for Valgus (with Short Leg) from Infantile Paralysis. (Galloway.)

Boots.—The boot may be made corrective by being raised at its inner border by thickening the inner side of the sole and heel. This is a modification of the method originally introduced by Thomas in the treatment of flat-foot, in which the whole sole of the shoe is raised along the inner border by means of a wedge. This method is often of use in children, in whom the sole should be thickened from a quarter to half an inch. The amount necessary may be determined experimentally by blocking up the inner

side of the foot till the correct position is obtained. In adults, with notably too much weight borne on the inner side of the foot and slight symptoms, a raise of from one-eighth to one-quarter of an inch is often efficient treatment. The objection to the method is that the foot slides on the incline of the sole and bears uncomfortably hard on the outer border of the boot, sometimes causing irritation over the base of the fifth metatarsal and often distorting the boot by stretching of the leather over the outer side. The less the amount of raising the sole, the less is the likelihood of this objection to the treatment. The attempts to correct any but the mildest grades of weakened foot by the use of corrective boots are generally unsatisfactory. Boots stiffened along the sides of the ankle for the use of children with weak ankles so commonly sold are useless, and the leather reinforcement of the inner side of the boot for adults is generally unsatisfactory. No matter how much this reinforcement is stiffened it will naturally yield, and as a rule affords only temporary support.

The use of proper foot wear is sufficient to correct the mildest cases, and in connection with proper hygiene and exercises is in these cases

a *b* *c*

FIG. 605.—*a*, Print on Smoked Paper of a Pointed Shoe; *b*, imprint of foot wearing pointed shoe, both indicating compression of the front of the foot; *c*, print of workingman's shoe, showing proper room for toes.

sufficient to effect a cure. The adoption of proper foot wear is also to be regarded as a prophylactic measure deserving consideration. The requirements of a proper boot or shoe are to be determined from what

has been said of the normal foot and of the causation and pathology of the weakened foot. Its object should be, of course, to support the foot in an approximately correct position. It is obvious that the great toe

a *b* *c*

FIG. 606.—Children's Shoes. *a*, Compressing the toes; *b* and *c*, giving room for the toes.

FIG. 607.—Modern Shoe, Necessarily Compressing Toes.

should have room to help support the inner border of the foot; that the fore-foot should not be cramped, but should have room to be placed properly on the ground in order to perform its weight-bearing function properly; and that the toes should be given room and opportunity to touch the ground in their proper relation and thus be of use in walking.

FIG. 608.—Boot of Improved Pattern. (Inner edge not so straight as it should be theoretically.)

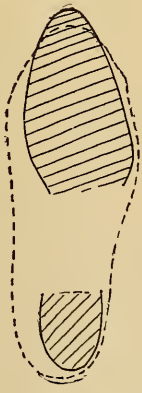

FIG. 609.—Ordinary Relation of Boot to Foot.

FIG. 610.—Last for Normal Shoe. (Galloway.)

These requirements necessitate that the boot or shoe should have a

straight inner line, that the shank should be as high as the shank of the individual foot when bearing slight weight, that it should be fairly stiff and not cut away at its inner border any more than is necessary for purposes of boot-making. The shank should be slightly higher at its inner than at its outer border. The forward part of the boot should be as wide as the weight-bearing foot at that point, and the toes should have room to be placed individually on the ground. The forward part of the sole should not be curved up as is usual, but should be flat to enable the toes to finish the step in walking; neither should the under surface of the sole be convex from side to side, but should set squarely on the ground. The heel should not be unduly high. The forward part of the boot should be at somewhat of an angle to the line of the long axis of the heel, that is, the fore-foot should be slightly adducted on the posterior part of the tarsus. Since the position of the weakened foot is one of abduction of the fore-foot, and the position of the foot under muscular support is one of adduction of the fore-foot, it is obvious that the support of the foot in the former condition is corrective in character.

FIG. 611.—Flat-foot Boot. (Galloway.)

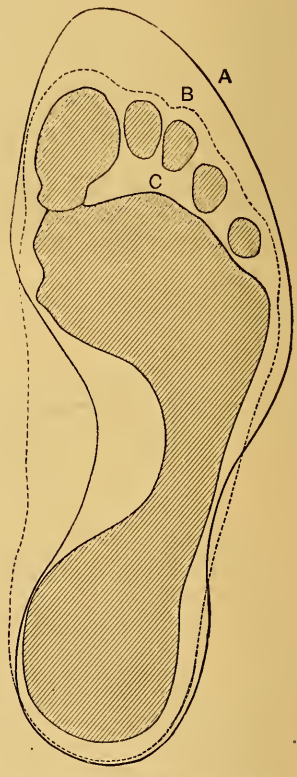

FIG. 612.—Proper Relation of the Sole to the Shape of the Foot. *A*, Outline of sole; *B*, outline of foot; *C*, imprint of foot. (Whitman.)

Measures to stimulate the local circulation are necessary in both the weakened and in flat-foot. Massage and electricity are of assistance. Douching alternately with hot and cold water is a measure of value. The

feet should be soaked for five or ten minutes in water as hot as can be borne and then douched with cold water. The hot-air bath is also of assistance.

Gymnastics.—Exercises to increase the power of the deficient muscles are sufficient, in connection with the measures already mentioned, to correct many of the milder cases. They form an important part of the treatment of all cases, mild or severe, whether or not used in connection with support to the arch, and are to be regarded as essential to treatment of any form.

The most notably deficient muscles are the tibialis posticus, the flexor longus hallucis, and the short muscles of the sole of the foot. Among the exercises most commonly useful are the following. They should of course all be taken without boots. The patient stands with the feet turned out, rises slowly on to the toes, turns out the heels, and sinks slowly to the ground.

The patient walks with the feet held in the position of talipes varus, the attitude of the feet being kept up by strong muscular contraction.

The patient learns to separate the great toe from the second toe laterally and to hold it in that position while walking.

The patient learns to flex the toes while the foot is free and to grasp objects in them by their plantar surface.

The patient sits with the leg extended and resting upon the assistant's knee. Forcible adduction of the fore-foot is then made while the assistant resists lightly with one hand steadying the tibia and the other pressing against the ball of the great toe.

The patient should be taught to rise on the toes at the end of each step, finishing the step with the toes.

Such exercises as the surgeon selects should be performed an increasing number of times each day.

Morton's Disease.

(Metatarsalgia or Anterior Metatarsalgia.)

This name is used to describe a cramping pain more or less spasmodic, situated between the distal end of either of the outer three metatarsal bones. It was first described by T. G. Morton,[1] of Philadelphia, in 1876, and has since that time been studied by other writers.[2]

[1] Amer. Journ. Med. Sciences, 1876; Phila. Med. Times, October 2d, 1886; Int. Med. Magazine, 1896 and 1897, v., 322.

[2] Bradford: Boston Med. and Surg. Journal, cxxv., iii., 52; T. S. K. Morton: Ann. of Surg., 1893, 680; Gibney: Am. Journal Nerv. and Mental Dis., September, 1894; Polasson: Lancet, March 2d, 1889, p. 436; Guthrie: Lancet, March 19th, 1892, p. 628; Woodruff: Medical Record, January 18th, 1890; Goldthwait: Boston Med. and Surg. Journal, cxxxi., p. 233; Robert Jones: Liverpool Med. Chir. Journal, January, 1897; Whitman: Orth. Trans., vol. xi., p. 34.

The condition is characterized by a severe neuralgic pain, coming on ordinarily during walking, which radiates down into the toes and often up into the leg. It occurs generally between the third and fourth or fourth and fifth toes. It may be preceded by a sensation of slipping between the ends of the metatarsals, or the slipping may occur without the pain. It ordinarily comes on when the boots are on, but may sometimes be occasioned by rising on the toes in the stocking feet. The patient seeks relief instinctively by removing the boot and rubbing the foot, which temporarily relieves or stops the pain. Some soreness may remain afterward and a tender spot is often found at the seat of the pain.

FIG. 613.—Radiograph Showing Compression of Left Foot by Boot.

When once established the attacks of pain become gradually more frequent and more severe. A neuralgic condition of the leg and foot is present in severe cases, and the patient learns to avoid walking. Spontaneous recovery may occur, but is uncommon.

On inspection the foot may be, so far as can be ascertained by examination, perfectly normal in every respect. Oftener, however, one or more of the following variations from the normal may be detected.

(1) The foot may be weakened and of the type described at the head of this chapter. Flat-foot almost never coexists.

(2) The anterior arch of the foot may be relaxed and flattened, the

dorsum of the foot depressed behind the toes, and the front of the foot broadened.

(3) The anterior arch of the foot may be rigidly held in a depressed position.

(4) Dorsal flexion of the foot may be limited on manipulation.

FIG. 614.—Radiograph Showing Right Foot Uncompressed by Boot.

Motion of the toes, especially in severe cases, is apt to be limited in the direction of plantar flexion.

The pain is evidently due to some disturbance in the normal relation of the anterior ends of the metatarsal bones. Morton thought that it was due to pinching of the external plantar nerve between the fourth and fifth metatarsal bones. Woodruff and Jones attributed it to a direct downward pressure of the metatarsals on the digital nerves in the sole of the foot. Jones quoted Tubby as finding one of those nerves swollen and congested on microscopical examination in a case operated upon.

The origin of the condition is obscure. It may be traumatic in some cases, but it is most often obviously associated with the wearing of improper boots. Yet in some instances a tight shoe is less uncomfortable than a loose one. It is probable that compression of the anterior part of the foot by ill-fitting boots is in most cases the cause of the affection.

Although the real condition is often overlooked, and a diagnosis of

neuralgia made, for which only general treatment is prescribed, yet the diagnostic symptoms are perfectly well marked and definite and not like those of any other affection.

FIG. 615.—Meyer's Line in Average Foot.

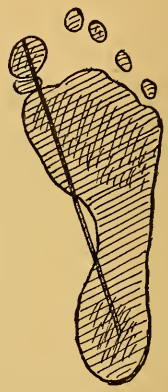

FIG. 616.—Meyer's Line in Normal Foot.

The prognosis without treatment is not good, the attacks as a rule become more frequent and painful, though spontaneous recovery does rarely occur. With proper mechanical treatment most cases recover, but

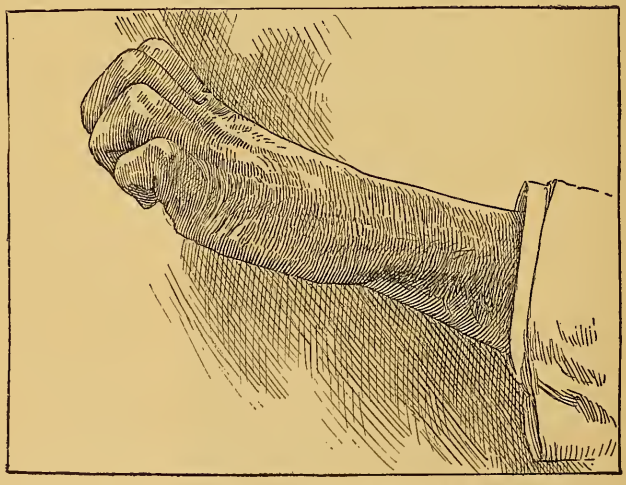

FIG. 617.—Position of Hand in which Lateral Pressure causes Pain at Metatarsal Heads. (Whitman.)

occasionally very obstinate cases are seen which resist all the ordinary methods of treatment.

Treatment.—It is obvious that if any static deformity of the foot exists it should be corrected. If the weakened foot is present a proper plate should be applied, brought well forward with an elevation behind

the distal ends of the metatarsals. If the gastrocnemius is short it should be stretched. If the anterior arch is relaxed and flattened a felt or metal pad should be placed under it behind the heads of the metatarsals. In short, measures should be adopted to relieve the front ends of the metatarsals from pressing down on to the sole of the foot in finishing the step in walking.

Proper boots with a broad sole should be worn, and compression of the front of the foot by boots should be avoided. The normal flexibility of the toes should be cultivated by proper exercises. In some cases,

FIG. 618.—Normal Motion of the Front of the Foot.

however, compression of the shafts of the metatarsals for a time affords relief. In these cases it can be afforded by adhesive plaster, by bandaging, or by a boot made tight over the shafts of the metatarsals. Removal of the distal end of the fourth metatarsal has been advocated as a measure of treatment, but it is not often necessary to resort to this.

DEFORMITIES OF THE TOES.

Hallux Valgus.—This name is applied to the outward displacement of the great toe. In the normal foot as seen in children and people who do not wear boots the long axis of the great toe when prolonged backward passes through the centre of the heel (Meyer's line). (See Fig. 603.)

This deformity of the great toe, however, is not necessarily the result of tight shoes, for the deformity may come in people who have worn only comparatively loose ones. The upper leather of shoes being more yielding than the sole, it stretches under the pressure of use, or is stretched to avoid pressure upon the metatarso-phalangeal articulation. The boot is not stretched at its extreme end, and it inevitably becomes, in a degree, conical in shape on this account, being broader across the ball of the foot than at the tip end. In the act of walking the foot necessarily slips inside of the boot to a certain extent, and if the shoe slips backward and the foot forward, a certain amount of pressure will come upon the inner side of the end of the great toe.

This deformity may also be occasioned by short boots, and the ordinary pointed-toe boots, or any boot which does not give more room for

lateral spreading at the toes than at the metatarso-phalangeal articulation, would necessarily give rise to the trouble.

When the deformity continues for any length of time, alteration of the bones of the metatarso-phalangeal joint takes place. The head of the metatarsal is partly uncovered as the phalanx is pushed to the outer side, and the head of the metatarsal may become enlarged from growth of the bone due to periosteal irritation. The skin over this prominent bone may grow thick and a bursa form on the outer edge. This may become inflamed, giving rise to an extensive cellulitis, which may include the whole dorsum of the foot, which may suppurate and cause necrosis of the bone. This latter termination is, however, rare and occurs only in neglected cases.

The symptoms due to hallux valgus in the non-inflammatory stages are chiefly those resulting from the alteration of the shape of the foot. In aggravated cases a peculiar gait is noticeable, the foot is thrown out and there is loss of elasticity in the gait. There may be pain, and in the severe cases extreme pain and difficulty in walking, which is usually attributed by the patient to gout. It is almost exclusively an affection of adult life, but is occasionally seen in adolescence. In old age it is often found in conjunction with chronic rheumatoid arthritis, or with bunion. On examination sensitiveness of the metatarso-phalangeal joint is detected on pressure.

Treatment.—The treatment of hallux valgus in children is best carried out by wearing a splint of steel or hard-rubber along the inner border of the foot fastened behind to the metatarsus. To the front end of this splint the toe is bandaged or strapped and thus pulled outward.

The use of a toe post is sometimes beneficial. That is, a metal partition is attached to the sole of the boot, which shall come between the first and second toes and hold the great toe in an improved position. For the use of this toe post a stocking is required which shall have a division between the great toe and the other toes.

The use of a foot plate curved to support the arch of the foot may be of use when the foot is weakened or flat.

Shoes should be so constructed that no pressure is possible which will force the great toe to the outer side. The sole of the shoe should be not only as broad as the sole of the foot, but in cases in which there is a tendency to this deformity, there should be room made in the front of the shoe for the first metatarso-phalangeal joint of the large toe to move to the inside.

In old cases attempts to correct the deformity by such means as those mentioned are generally unsuccessful and operative measures may be adopted.

The joint may be resected through an incision along the inner and upper surface of the joint, the section of the bones being made in such

planes that the cut ends of the bones when in apposition keep the toe in its proper position. A wedge-shaped osteotomy of the first metatarsal behind the joint will correct the deformity in many cases and has the advantage of not destroying the joint surfaces.

Resection of the joint may be performed through an incision made between the first and second toes. By this method the cicatrix is not subjected to the friction of the boot. The use of properly made shoes is essential for after-treatment, and also for the prevention of the increase or recurrence of the deformity.

Bunion is the name applied to an inflammation of a bursa which forms on the inside of the metatarso-phalangeal articulation, and in some cases to an inflammation of that joint itself. It occurs most often in connection with hallux valgus.

Hallux Varus.—This deformity is not a common one, and is known also as in-toe or pigeon toe. It is rarely of any importance, and although often congenital in origin, it may occasionally be seen in young children with flat-foot, and the writers have observed it in a few cases of over-corrected club-foot in which a valgus has resulted. It is also seen in connection with severe knock-knee at times.

This distortion does not generally require treatment, and the use of ordinary shoes is sufficient to correct the deformity.

Hallux Rigidus.—This deformity is sometimes seen in adolescents, consisting of an ankylosis at the metatarso-phalangeal joint of the great toe. The deformity consists of a forced flexion of the proximal phalanx of the great toe through 30° to 60°, with extension of the second phalanx.

The symptoms vary with the stage of the disease. Early there may be slight pain over the joint and painful motion, but the cases rarely come to the surgeon's notice at this time. Later there is swelling over the joint, with rawness and tenderness, and perhaps an enlargement of the bone itself. If the disease progresses, the joint becomes ankylosed in the distorted position and the fascia and muscles contract and still more firmly secure the deformity in position. The usual atrophy after ankylosis often occurs here.

The condition is often associated with flat-foot. Ill-fitting shoes also have an influence in causing the distortion. At times it arises from an injury.

The treatment in the early stages will consist in removing the exciting cause, and properly supporting the foot. If there is pain, with signs of inflammation, rest with local applications is indicated, and later protection by splints with support of the arch of the foot. In inveterate cases excision of the joint may be necessary.

Hammer Toe.—This deformity consists of a claw-like contraction of one of the toes, usually the second or third. The condition is one of flexion of the second phalanx, with extension of the third, so that the

pressure on the ground is sustained by the *distal* phalanx. Over the upward projecting joint there is usually a callosity, which may cause considerable annoyance.

The origin of the deformity is not well understood, but in some cases it is apparently caused by short boots.

In the slight degrees and early stages of the deformity, the patient experiences but little discomfort, and such cases are not, therefore, com-

FIG. 619.—Hammer Toe.

monly seen by the surgeon in this stage. Later, however, locomotion becomes difficult and painful.

In children and adolescents the deformity can generally in all but the severest cases be corrected by simple mechanical treatment. The toe should be bandaged or strapped to a rigid plantar splint, which can easily be made of tin. The strapping should be renewed often enough to keep the toe extended. In very severe cases and in adults the deformity is best remedied by amputation at the metatarso-phalangeal articulation. In children it can be corrected if necessary by subcutaneous section of the contracted fasciæ, forcible straightening, and fixation in a straight position by means of splints and adhesive plaster.

Amputation at the interphalangeal joint is of no use, as the proximal phalanx remains still elevated, so that the only operative procedure worthy of consideration is amputation at the metatarso-phalangeal articulation. After correction by mechanical means the deformity shows a tendency to recontract and must be carefully watched.

Other operations than amputation have been recently advocated for the relief of this condition. Adams divides the external lateral ligaments subcutaneously, and extending the toe keeps it on a metal splint for three or four weeks. Petersen removes the soft and tendinous structures from the under side of the affected toe. Terrier makes a longitudinal incision along the dorsum of the toe and removes with bone forceps the ends of the phalanges which form the affected joint, and then cutting away the bursa and the callus from the top the toe is dressed in the extended position. Cuneiform osteotomy has been done with perfectly satisfactory results.

Deviation of the Small Toes.—The other toes may be displaced from being crowded together, either in such a way that one toe is forced to lie upon or over the others. This is almost invariably an acquired affection, but may rarely be seen in the feet of infants. This crowding may

also cause the toe to double on itself in such a way that the head touches the ground at the end of the nail, instead of on the pulp. This forced flexion may become so severe as to give much annoyance, causing an ulceration at the end of the toe and an inflamed bursa on the dorsum. This position of the toes may also be the result of unequal power of the antagonistic muscles.

In children and in light cases, the deformity may often be corrected by replacing the toe and securing it in position by winding adhesive

FIG. 620.—Bony Spurs on Upper and Lower Surfaces of Os Calcis. (Painter.)

plaster about it and a contiguous toe, which may serve as a splint, and by attention to proper shoes.

In adults and in pronounced cases, amputation is the only satisfactory method of treatment.

A contracted position of several toes is sometimes seen, either as a result of improper shoeing or as a sequel to a previous paralysis of some of the muscles of the foot. It also occurs at times in connection with what has been spoken of as contracted foot. The tendons and fasciæ will be found shortened.

This deformity is to be treated in the same way as the contraction of one toe. In this, as in all similar affections of the toes, properly made shoes are necessary to prevent relapse or to secure permanent recovery.

It is safe to say that, in obstinate cases, all contracted fasciæ or tendons should be freely divided.

The various joints of the toes may become inflamed and ankylosis of the metatarso-phalangeal articulation may occur; for the former, Thomas' shoe, which keeps the toe at rest, is of use. It has been described in speaking of the diseases of the ankle- and foot-joints.

Tuberculosis of the diaphyses of the metatarsals occurs at times in children.

Miscellaneous Conditions.

Painful Heel.—A condition is occasionally seen in which severe pain and tenderness are present in the heel at the posterior attachment of the plantar fascia. This has been spoken of as "policeman's heel." The

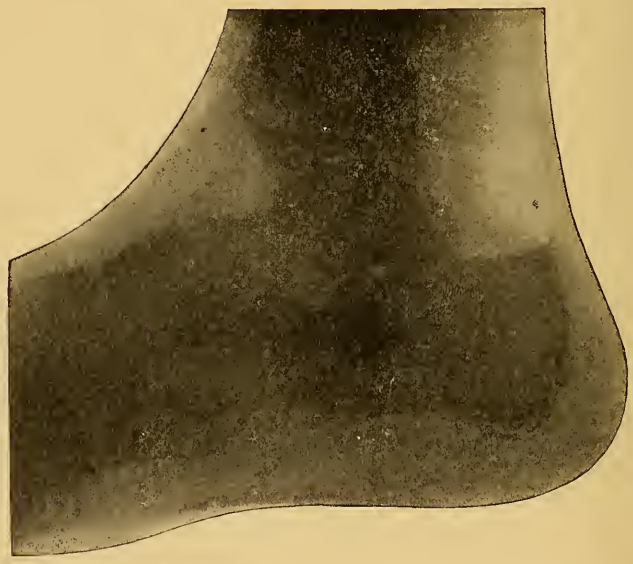

Fig. 621.—A Bony Thickening on Upper Surface of Os Calcis, which was Removed. (Painter.)

etiology of the affection is obscure, in some cases it is accompanied by exostoses of the os calcis.

Exostoses of the tarsal bones, especially of the os calcis, are found from time to time accompanying a painful and even a disabling condition of the foot. Inflammation of the post-calcaneal bursa has been described in connection with this condition.[1] The exostoses are found by skiagraphs.

The etiology is obscure. In some cases gonorrhœa may have preceded it, while in others there is no evidence of it. The affection is obstinate and recovery slow. It is not, as a rule, much benefited by treatment, and the removal of the exostoses has not regularly been followed by relief and should not be undertaken in the very acute stage.

[1] Painter: Orth. Trans., vol. xi. (with bibliography).

Rest, dry heat, fomentations, douching, massage, etc., all have their place in improving certain cases. Partial relief is often to be obtained by the use of a support to the arch of the foot, relieving the heel from some of its pressure.

Nodules in the plantar fascia are occasionally found in connection with arthritis deformans.

Pied Forcé.—A painful condition of the foot known as pied forcé has been mentioned by French surgeons as occurring generally among soldiers who are obliged to take prolonged marches. A swelling on the dorsum of the foot occurs, accompanied by pain and functional disability. This condition is followed often by exostoses, oftenest on the second metatarsal bone. It was formerly thought to be due to a periostitis or synovitis, but investigations[1] by means of skiagraphs have shown a bony deformity of the metatarsals resembling that which follows fractures.

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[1] Boisson and Chapotot: Arch. de Méd. et de Pharmacie Militaire, February, 1899.

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